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# SIZE AND FORM PERCEPTION IN *GALLUS DOMESTICUS*

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Four figures

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## I. APPARATUS

A frequent defect appearing in past experiments on visual acuity in animals is the inadequate description of methods. In many cases the conditions have been such that they could not be accurately described. Complexities have been involved making it impossible to ascertain with certainty the visual factors on which the animals have relied in their discriminations. The apparatus used in the observations which are reported in this paper was devised for the purpose of overcoming this difficulty. Controllability was the primary aim in its construction.

To Professor Yerkes, under whom this study was made and to whom I am indebted for assistance and suggestions, credit is due for many of the points of method here described. A report has been published by him and Professor Watson[1] in which the details of parts of the apparatus have been presented. For the detail of divisions *2* and *3* the reader is referred to the Yerkes and Watson report. In order to give a comprehensive idea of the mechanism, I shall describe the complete apparatus as it appeared during my work, abbreviating, as much as possible, descriptions of the parts which have been previously described.

Figure 1 is an isometric view of the apparatus as a whole showing only the skeleton of the different parts when assembled for experimental work. I shall speak of that part of the mechanism labelled I as the *experiment box.* The opposite end, III, is the light or *source box.* Between the experiment box and the source box is a *stimulus shifter*, II. The whole apparatus was set up in a dark room. The only sources of illumination were the lamps in the source box and a lamp, L, hanging directly above the experiment box. With these sources cut off, a dark adapted human eye could see slightly, for a few small cracks in the room allowed faint rays of light to enter; but the subsequent description will show that these factors were of no consequence.

As a means of testing the chicks' ability to discriminate between sizes and forms, two illuminated areas differing from each other with respect to one or both of these factors are simultaneously exposed before the experiment box, I. The problem for the animal is to learn regularly to choose one of these stimuli and to reject the other. It is punished by means of an electric shock for a wrong choice and is rewarded for a right choice by escape to a warm, dry nest box where food, light, water, and companionship are to be found. The illumination of the visual stimuli comes from the source box, III, which is constructed so that the brightness of either stimulus area may be independently controlled. The light is admitted to two of three regulated apertures in the shifter, II, the function of which is to facilitate changes in the size, form, or relative position of the stimulus areas.

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[1] Yerkes, Robert M. and Watson, John B. Methods of studying vision in animals. *Behavior Monographs*, 1911, vol. 1, no. 2, S. N. 2.

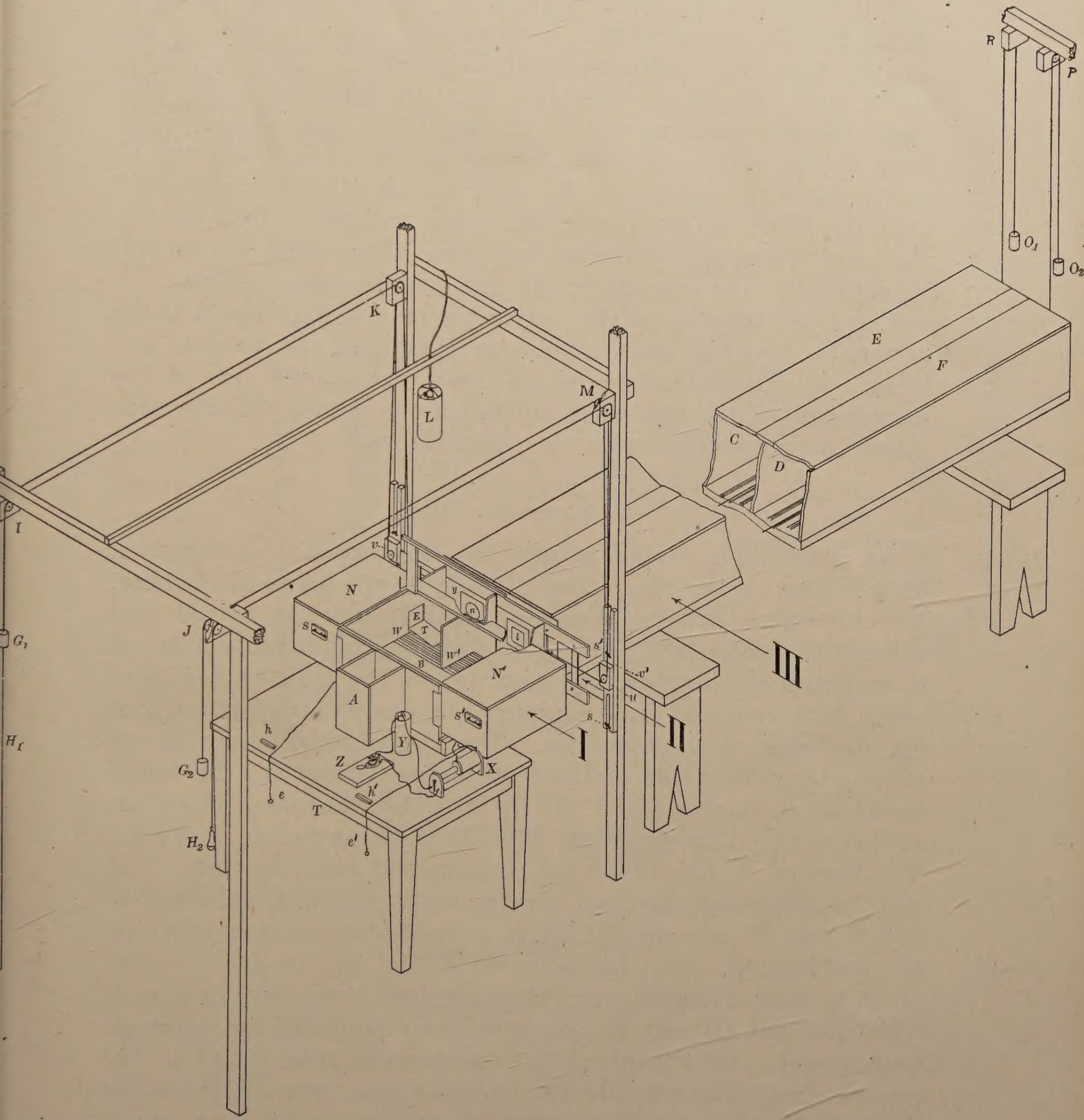

Figure 1. Isometric view of *light* vision apparatus.

If the form of the two end stimulus areas is square, and that of the middle one is circular, a movement of the adapter to the left produces the condition shown in figure 1. The stimulus *l*, at the right is a square and that, *n*, at the left is a circle. But when the shifter is moved to the right and the relative positions of the two forms with respect to each other become reversed since the square at the extreme left (now invisible) will take the place of the circle, the circle will move over to the place now occupied by the square, while the present square will be shifted to the extreme right and will become invisible.

This brief account of the apparatus as a whole should make it possible to grasp more easily the details of the various sections. An understanding of the construction and use of the mechanism will be made less difficult if the details are now considered in connection with each general part.

### 1. *Experiment box*

An illustration of the experiment box appears as figure 2. This section of the apparatus is made of one-half inch lumber, (except where stated otherwise), and is painted within and without a dead black. It consists of four main parts: (1) A is an entrance chamber, 15½ x 20 x 22.[2] The floor of A is provided with a metal tray containing a piece of wet felt which fits the floor of the chamber. The entrance box may be removed by raising out of the iron straps, C and C′, the board to which it is attached. (2) B is a discrimination chamber, 26 x 51 x 22. Leading from A to B is an entrance, I, 8 x 10. The floor of B, like that of A, is carpeted with wet felt. The tray of either compartment can be easily removed and cleaned. (3) W and W′ are electric boxes separated from each other by the partition D. On the floors of W and W′ are fitted pieces of slate, 16½ x 24¾ x 1, carrying electric wires by means of which an animal can be shocked when its behavior demands punishment. By means of the interposited sides, O O O, the electric compartments are set back 14 cm. from the stimulus shifter. The floor of this extended portion drops down about 10 cm. below that of W-W′. The middle O stands up closely to the adapter so that the exposed stimuli are set off from each other. On the end of DO is glued a piece of piano felt, P, which rubs snugly against the shifter and prevents any intermingling of the stimulus illuminations, while at the same time, the shifter can be freely moved in either direction without becoming scratched or marred by the friction. (4) N and N′ are nest boxes, 40½ x 22 x 22. Each nest box is covered by a tightly fitting lid, which is hinged at the outside, and is equipped with a 2 c.p. electric lamp (frosted globe), L, a watch glass for water, G, and sand or litter in which food may be scattered. It is also provided on the outer side with hidden holes for ventilation.

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[2] Unless otherwise stated, dimensions are given in centimeters and the order of presentation is length, width, and depth—inside measurements.

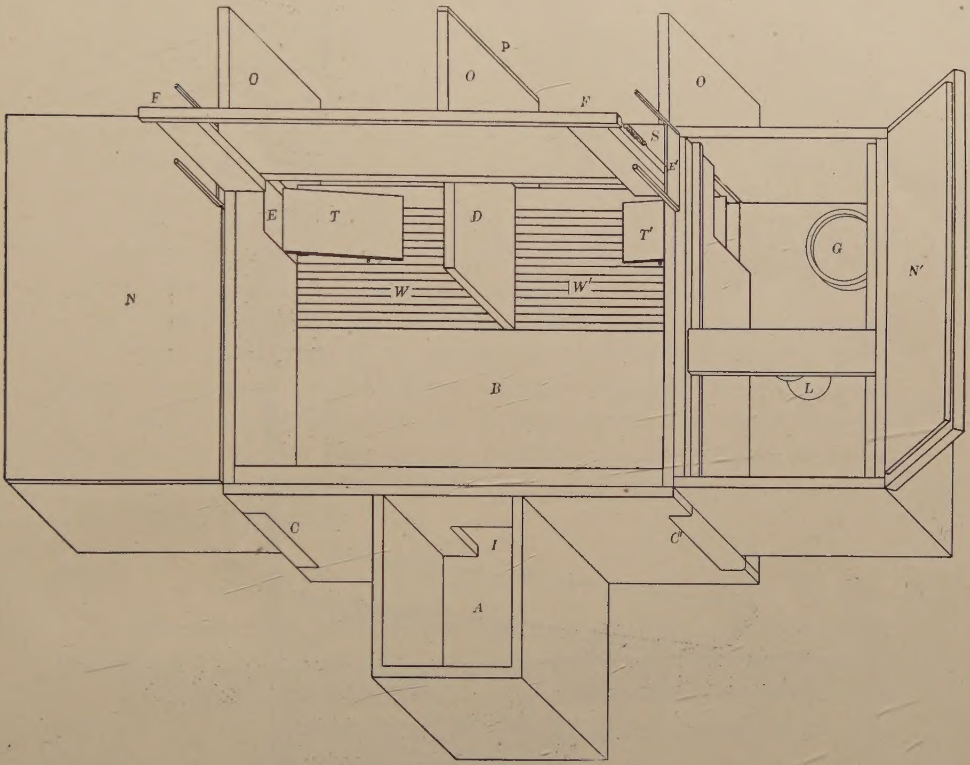

FIGURE 2. Experiment box

Between W and N, also W′ and N′, is a vertically sliding door, E closed and E′ open, 3 mm. thick which fills an opening 8 x 10. Suspended from an upright frame, F, is a coiled spring, S, which passes through the walls of N′ and B-W′ to the top of E. When E is closed S is extended and in a state of torsion, hence when E is released S tends to return to a state of rest and the doorway is opened. The method of closing the doorway may best be seen in figure 1. A silk line, *e*, which passes up through a wire loop directly under E is attached to the lower part of the door. By pulling on *e* the experimenter can close E which automatically locks when it is closed. By stepping on or striking T the chick can release the lock. The experimenter, however, by catching *e* on the hook *h* can prevent the door from opening when the T-lock has been released. This automatic release was devised by Professor F. S. Breed.

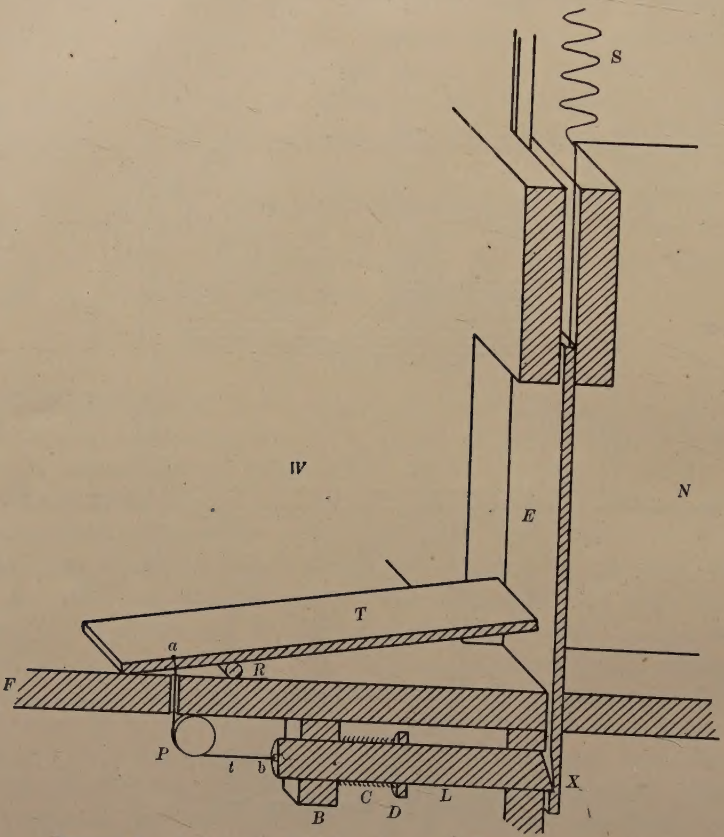

**Figure 3.** Automatic tripping device of the experiment box.

The construction of this mechanical device for opening E appears in figure 3 of which T is the trip that was seen in the other figures and *t* is a short piece of No. 30 black thread attached to T at *a*. Passing down through the floor, F, of the electric box, W, *t* runs over a pulley, P, and is fastened to the spring lock, L, at *b*. B is a block through which L passes and against which one end of the spring, C, presses. D is a stop attached to L supporting the other end of C. This spring tends to force L in the direction of X and to keep T in the position as illustrated. But when sufficient pressure is applied to T at any point above R, L is forced back in spite of the pressure of C, E is released at X, and the recoil of S raises E. When E is drawn down, L, by reason of the slanting end surface at X, is forced toward P until the notch of E has passed below the lower side of L when the constant pressure of C toward X forces L into the notch of E and the door is again locked.

In several respects figure 3 is a very poor representation of the tripping device. L is shown as constructed solidly in B, when, in reality, it slides very freely through B. Moreover, L is sadly disproportioned for it appears in the figure as wide as the floor of the experiment box, but it is really a delicate latch narrower than the width of T or E and is released by a very light touch upon T.

### *2. Source box*

To provide illumination for the two stimuli simultaneously presented to the chick, the source box represented in figure 4, —III of figure 1,—was used. A complete description of this part of the mechanism appears in Behavior Monographs, *loc. cit.*, p. 17*ff*.

### *3. Stimulus shifter*

Figure 4 also presents a general view of the stimulus shifter by means of which size, form, position, and, in conjunction with the lamp carriages, brightness of the visual stimuli can be regulated. The details of the stimulus shifter or adapter appear in the Yerkes and Watson report.

A considerable number of standard brass stimulus plates, used for varying the size and form of the visual stimulus, is required if an animal's discriminative ability is to be deter-

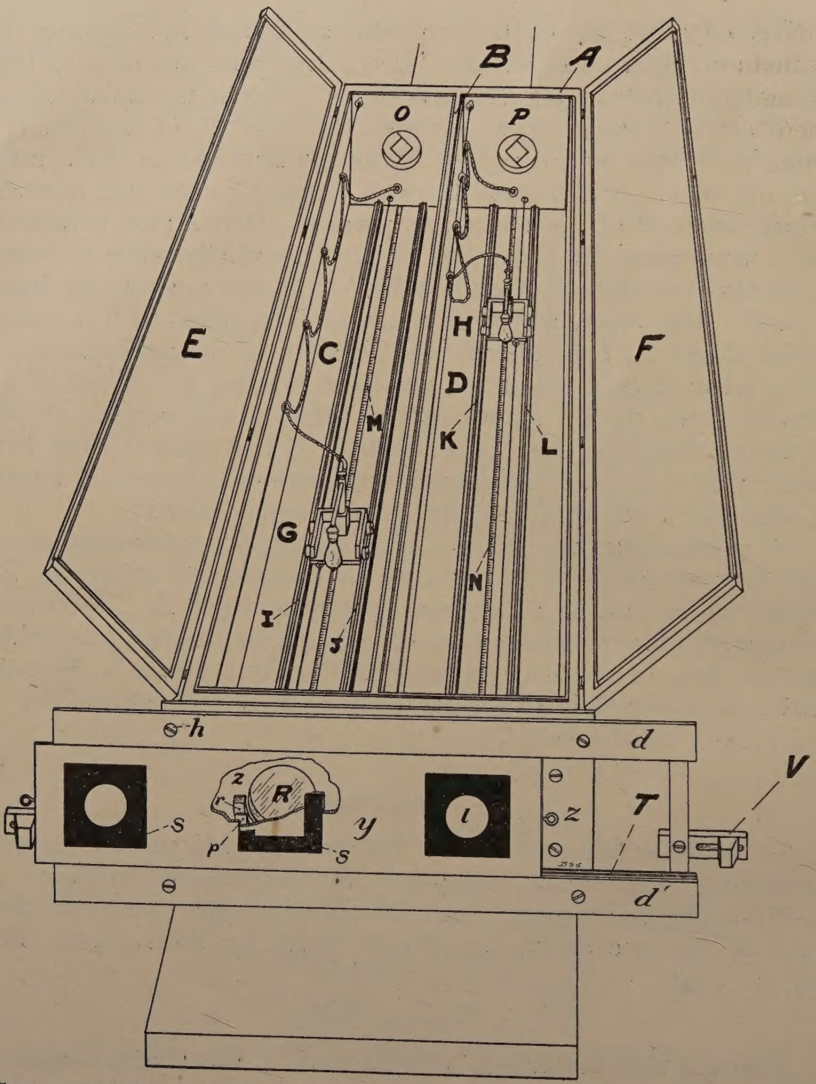

Figure 4. (Reprinted from *Behavior Monographs*, 1911, vol. 1, no. 2, p. 18.) "Perspective of *light* or 'brightness' apparatus. A, light box; C, D, compartments of A; B, partition between C and D; E, F, lids of A; G, H, metal carriages carrying tungsten lamps; IJ and KL, tracks for G and H; M, N, Starrett steel millimeter tapes; O, P, apertures covered by Aubert diaphragms; R, Bausch and Lomb cooling cell in light box; d, d′, metal straps; y, aluminum plate sliding between d and d′; T, tracks for y; V, stop for y; z, steel plate bolted to wooden end of light box; h, screws attaching y to z; s, s, standard brass stimulus plates; p, brass frame about aperture in y; r, hard rubber ring screwed to p."

mined. Part of the set I used, which consisted of 47 plates, is included in table 1. Owing to the variations in sensitiveness among different subjects, a set which would meet the requirements for one animal would not suffice for another, hence, in those cases where the size differences among the plates vary by one millimeter, a safe margin has been allowed by enumerating a few more plates than would ordinarily be required, and those plates for which I found no use have been omitted.

### *4. Accessories*

Connected with both ends of the stimulus shifter, II, figure 1, page 67, are two ropes which pass over several pulleys and terminate at $H_1$ and $H_2$. These ropes hang 85 cm. back of the table, T, thus leaving the experimenter an abundance of free space at the front of the apparatus. They are separated from each other by 110 cm. The purpose of this attachment is to enable the experimenter to change the position of the shifter without leaving his place of observation. As is shown in the initial figure, the shifter can be moved from its present position to the right side by pulling on $H_2$. $H_1$ would thus be raised, and by pulling on it the adapter would be returned to its present position. The stops $v$ and $v'$ are so adjusted to the shifter that the openings in the brass plates will fall directly in the line of illumination from the source box. These stops are horizontally adjustable (not shown in the figure). The center of the pulley which $v$ carries is 92½ cm. above the floor. The pulleys at I, J, K, and M are 230 cm. from the floor. The distance from I to K and from J to M is 200 cm.

Arranged upon the same frame is another system of ropes and pulleys devised to control the positions of the source lamps. The terminals of these ropes are indicated by $G_1$ and $G_2$ at the experiment end, and by $O_1$ and $O_2$ at the opposite end. The drawing accurately represents the actual conditions at the experiment end, but on account of the arrangement of the walls of the dark room, $O_1$, $O_2$, R, and P merely represent the principle of the system. The ropes $G_1$-$O_1$ and $G_2$-$O_2$ are centrally attached to the source carriages of C and D. By lifting slightly upon $G_1$, $O_1$ begins to lower and draws back the lamp carriage through C. By lightly pulling down upon $G_1$, the carriage in C is drawn forward. The system $G_2$-$O_2$ works similarly.

TABLE 1

Stimulus Plates

| Use | Form | Diameter or Side | Area | Number Plates Needed |
|---|---|---|---|---|
|  |  | cm. | sq. cm. |  |
| To test Size Perception | Circle | 1.8 | 2.5447 | 1 |
| " | " | 1.9 | 2.8353 | 1 |
| " | " | 2.0 | 3.1416 | 1 |
| " | " | 2.1 | 3.4636 | 1 |
| " | " | 2.2 | 3.8013 | 1 |
| " | " | 2.3 | 4.1548 | 1 |
| " | " | 2.4 | 4.5239 | 1 |
| " | " | 2.5 | 4.9088 | 1 |
| " | " | 3.0 (standard) | 7.0686 | 2 |
| " | " | 3.5 | 9.6211 | 1 |
| " | " | 4.0 | 12.5664 | 1 |
| " | " | 4.1 | 13.2026 | 1 |
| " | " | 4.2 | 13.8545 | 1 |
| " | " | 4.3 | 14.5220 | 1 |
| " | " | 4.4 | 15.2053 | 1 |
| " | " | 4.5 | 15.9043 | 1 |
| " | " | 4.6 | 16.6191 | 1 |
| " | " | 4.7 | 17.3495 | 1 |
| " | " | 4.8 | 18.0956 | 1 |
| " | " | 4.9 | 18.8575 | 1 |
| " | " | 5.0 | 19.6350 | 1 |
| " | " | 5.5 | 23.7583 | 1 |
| " | " | 6.0 (standard) | 28.2744 | 2 |
| " | " | 6.1 | 29.2247 | 1 |
| " | " | 6.2 | 30.1908 | 1 |
| " | " | 6.3 | 31.1725 | 1 |
| " | " | 6.4 | 32.1700 | 1 |
| " | " | 6.5 | 33.1832 | 1 |
| " | " | 6.6 | 34.2120 | 1 |
| " | " | 6.7 | 35.2566 | 1 |
| " | " | 6.8 | 36.3169 | 1 |
| " | " | 6.9 | 37.3929 | 1 |
| " | " | 7.0 | 38.4846 | 1 |
| " | " | 7.1 | 39.5920 | 1 |
| " | " | 7.2 | 40.7151 | 1 |
| " | " | 7.3 | 41.8540 | 1 |
| " | " | 7.4 | 43.0085 | 1 |
| " | " | 7.5 | 44.1787 | 1 |
| " | " | 8.0 | 50.2656 | 1 |
| " | " | 8.5 | 56.7455 | 1 |
| " | " | 9.0 (standard) | 63.6174 | 2 |
|  |  |  |  | 44 |
|  |  | cm. | sq. cm. |  |
| To test Form Perception | Circle | 6.0 (as above) | 28.2744 | – |
| " | " | 5.9 | 27.3397 | 1 |
| " | " | 5.8 | 26.4208 | 1 |
| " | " | 5.7 | 25.5176 | 1 |
| " | " | 5.6 and smaller circles used in size perception | 24.6301 | 1 |
| " | Square | 5.317 (side) | 28.2743 | 2 |
| " | Equilateral △ | 8.081 (side) | 28.2743 | 2 |
|  | *Openings inscribed in circle—28.2744* |  |  |  |
| " | Square | 4.243 (side) | 18.003 | 2 |
| " | Equilateral △ | 5.196 (side) | 11.691 | 2 |
|  |  |  |  | 12 |
|  |  |  |  | Total 56 |

The experimenter is thus enabled to control the intensities of the stimulus areas without leaving his end of the apparatus. By moving a carriage backward the intensity of the corresponding stimulus display is decreased; by drawing the source nearer, the intensity is increased.

Figure 1 also shows arranged on a table, T, the electrical connections with the experiment box. X, Y, and Z are respectively an inductorium, a Columbia dry cell (No. 6), and a telegraph key which, in connection with the wired slate floors of W and W′, constitute an interrupted circuit. The wires are wrapped alternately about the slate floors so that by closing the key, Z, a chick, when its feet touch any two of the wires, can be shocked. With young chicks under two weeks of age it was found necessary in general to set the secondary coil at 5, but as they become older and heavier the strength of the shock had to be decreased, until, in some cases, the position of the secondary coil was as far out as 6.5. The letters *s* and *s′* indicate electric switches by means of which the illumination in N and N′ can be turned on or off. An upper illumination, L, designed to hide inequalities in the distribution of light in each compartment, W and W′, hangs about 120 cm. above the floor and directly over the center of the electric boxes. It consists of a 2 c.p. electric lamp inclosed in a vertically suspended cylinder of galvanized iron. The diameter of this cylinder is 10 cm. and its length is 20 cm. The upper end is closed. The lower end is fitted with a cover (like that of a baking powder can) which may be pushed on or off. Centered in this cover is an Aubert diaphragm by means of which the amount of light falling on the experiment box may be regulated. On account of the low ceiling of the dark room where these experiments were conducted, I found it impracticable to use the diaphragm. Unless it can be raised to a sufficient height it will cast shadows upon the floor of the experiment box. With the diaphragm removed, the upper illumination consisted of the rays from a 2 c.p. lamp passing through a circular opening 10 cm. in diameter and falling a distance of 120 cm.

The importance of L will be understood more thoroughly in connection with the conditions for size discrimination. If a chick is being trained to choose ⊙ 28+,[3] (a circle whose area is 28.2744 sq. cm.), and to reject ⊙ 7+, unequal amounts of light from the stimulus sources will be admitted to the electric compartments. If the intensities of the two stimulus areas be equalized, the compartment at the end of which the larger circle appears will be the more highly illuminated. Without the elimination of this factor of general illumination, the experimenter can not be certain that his animals are discriminating on the basis of size; they may be choosing the *lighter* compartment. To overcome this difficulty the upper illumination was used and the elongation of the electric compartments, O O O, figure 2, was introduced. The amount of upper illumination should therefore depend upon the degree of difference between the two stimulus areas, and in a quantitative study, where the difference is continually being reduced toward the minimum of the animal's discriminative ability, the difficulty practically disappears.

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[3] The dimensions of stimulus areas refer in square centimeters to the area.

A further value of the upper illumination is economy of time for the experimenter. It aids in emphasizing, from the first, the visual factor which is being tested and thus prevents the animal from acquiring a habit of discrimination which later must be inhibited and replaced by a different habit. After an animal once acquires a definite way of reacting to stimuli, no little time and pains are required to make it change its mode of response.

With the elongation of the electric compartments appears another difficulty differing somewhat from the matter of general illumination. This is the problem of the chick's optimal focal distance. It is quite possible that, for a stationary stimulus, the discrimination chamber of this apparatus is too far away. The anatomy of the eye as well as the behavior of the animal should be considered in connection with this problem. The matter of distance perception, however, falls without the scope of the present task.

## II. PROBLEM, METHOD, AND TECHNIQUE

### 1. *The chicks*

The experiments reported in this paper were made with about 25 chicks belonging to three different groups. The first group, originally consisting of 10 chicks, was secured from a poultry breeder when the chicks were about two days old. The second and third groups were artificially incubated in the laboratory. All of the chicks used were of the Barred Plymouth Rock variety. The matter of caring for the birds and keeping them healthy was one of the most serious difficulties which I had to overcome. On the whole, I found it more satisfactory to use the laboratory hatched chicks.

The most common ills were bowel trouble and "leg weakness." Both types of disease were chiefly due to improper feeding, temperature, and ventilation. My experience leads me to conclude that chicks in close confinement must be fed on "starving rations." A few individuals of group 3 survived until the weather became warm enough to get them out of doors during a few hours on favorable days. When this plan was first tried the birds were in poor condition. Two-thirds of the group had already died. But as soon as the survivors were placed out of doors their physical condition began to improve, and I was able to do nearly three times the amount of experimental work that I could formerly accomplish. Apparently the factors that healthy laboratory chicks require is an abundance of sunlight and fresh air with an opportunity to work for their living.

The "leg weakness" is a type of disease which had previously given trouble in the laboratory. The leg joints become enlarged, the toes curl out of shape, the birds cannot stand, and they move about only with great difficulty. This trouble ultimately carried off nearly all of the birds which did not succumb to bowel trouble. In the case of one brood I think it was the result of excessive heat in the brooder. In other cases it was probably due to overfeeding. More often, perhaps, it was due to a combination of both conditions. The birds which first showed signs of this weakness were the largest and apparently strongest of the flock. There was no evidence of it among the chicks of the third group, which were fed very sparingly, while the temperature of the brooder was carefully regulated.

### 2. *The problem*

The matter of health among the chicks turned out to be a problem which had not been anticipated. However, it did not prevent work toward the solution of the primary problem. The task originally planned was a study of the chick's discriminative ability between sizes, forms, and brightnesses, but, owing chiefly to these unfavorable conditions, little consideration has been given to the third factor. The present paper is a preliminary report of a detailed investigation which the writer hopes to complete within a few years.

As far as the study goes, the aim has been to make it intensive and quantitative. In the matter of size and form, the question has been, not merely: Can the chick discriminate between stimuli which differ from each other with respect to one of these factors, but What is the least difference that it can discriminate? Breed's work [4] has indicated that chicks *can* discriminate on these bases. The work of Katz and Révész [5] suggests the same possibility. My original plan, therefore, was to test this matter quantitatively and to determine the chick's threshold of difference for each of these factors.

With respect to size, I have carried out my original plan without any essential changes, but in the case of form, I was forced to abandon the plan with which I started. In a short time it appeared that proper responses to stimuli differing from each other only with respect to form were not so readily acquired as reactions to size differences. After I had tried in vain for several weeks to train different subjects to discriminate between a circle and a triangle which were equal in area, the nature of my problem was markedly changed. It was clearly necessary to determine whether the chick, under the conditions of this experiment, could perceive form.

Finally, another aspect of the problem which quite naturally appears in an investigation of this sort is that of the relative value of visual size, form and brightness. My earlier results with forms, negative beyond all doubt, emphasized the desirability of considering the factors in combination as well as in isolation. In its normal life the chick is not compelled to rely upon a single visual factor, but, on the contrary, it relies upon a natural combination of visual qualities. It thus seemed important to start with complex stimuli and from these gradually to eliminate the inequalities which were not wanted, until only the visual factor in question remained.

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[4] Breed, Frederick S. The development of certain instincts and habits in chicks. *Behavior Monographs*, 1911, vol. 1, no. 1, S. N. 1; also Reactions of chicks to optical stimuli. *Jour. Animal Behavior*, 1912, vol. 2, pp. 280-295.

[5] Katz, D. and Révész, G. Experimentell-psychologische Untersuchungen mit Hühnern. *Zeit. f. Psych. u. Physiol. d. Sinnesorgane*, 1909, Bd. 50, S. 93.

### *3. Method and technique*

These changes in the problem are closely allied with the mode of procedure. The mechanical phase of my method appears in the description of the apparatus, but it does not fully explain the application of this procedure to the study of the chick's visual perception. This topic might well be considered in two parts:—the one dealing with the mechanism, the *objective aspect*, and the other relating to the plan of procedure, the *personal aspect* or *technique*. In this report I shall not attempt to make such a sharp distinction, for while the two topics are, in many respects, clearly distinct, I find them so closely interrelated that it is impracticable to consider them separately. In general, however, I shall devote the first part of this section primarily to method, and in the latter part, the discussion will be continued more from the standpoint of technique.

The plan of the apparatus in relation to the chick is to provide conditions both desirable and undesirable. Either nest box includes those factors which the chick wants. It provides food, light, warmth and companionship. The experiment box is arranged to make the chick want to get out. In the entrance box the chick is closely confined; in both the entrance and discrimination chambers the floors are wet; the entire experiment box, exclusive of the nest boxes, provides faint illumination, little warmth, no food and no companionship. When a chick, familiar with the nest boxes, is placed in the entrance box its natural desire is to get back to one of the nest boxes. Its problem, then, is to learn how to get to the desirable part of the apparatus.

The two visual stimuli which are displayed on the stimulus shifter indicate to the animal which nest box to choose. During the training series, both electric compartments are identical except for the difference between the two stimulus areas. Since the animal wants to reach the nest box it will try to find a way of accomplishing this end.

Each chick was taught the way of escape to the nest box by means of 20 preliminary trials. The entrance to the nest box on that side where the *right* stimulus appeared was open; the sliding door closed the entrance from the electric box where the *wrong* stimulus was presented. The chick was allowed to go now to one, now to the other nest box, in irregular sequence until it had found its way 10 times to each. It was thus made familiar with nest boxes and the experiment box.

By displaying, always on the side of escape, the stimulus which the chick was later to be trained to choose, the animal was occasionally aided in acquiring a perfect habit.[6] This condition was especially noticeable in the experiments on size discrimination. In this case a circle 6 cm. in diameter always appeared in that electric compartment from which the subject escaped. At the end of the preliminary series a few chicks had acquired a perfect response to this condition of ⊙ 28+—⊙ 7+ discrimination.[7] This perfect ⊙ 28+—⊙ 7+ habit, however, may not mean that size was the basis of choice. It is quite possible that the birds chose the lighter compartment. Precaution was always taken to eliminate this possibility before size tests were completed, and control tests were carefully planned to make certain that it *had* been eliminated.

This preliminary work was followed by the training series. Both entrances to the nest boxes were now closed, and the only cues that remained to aid the chick to reach the nest box were the two optical stimuli. Continuing the example of size discrimination, ⊙ 28+ was the positive sign, ⊙ 7+ was the negative sign of escape from the experiment box. At this point in the training the electric shock was introduced. If a chick chose ⊙ 7+, *i.e.*, stepped upon the wires of that compartment, it was shocked. This was done by momentarily closing the key, Z, (figure 1). A single shock was usually given, but if the behavior of the bird indicated that the shock had not been sensed, it was repeated. The wet floors of A and B served to regulate the intensity of the shock. Great care was necessary to provide a shock that was an effective punishment yet not severe enough to frighten the animal. Care in the manipulation of the shock was also essential. The results of weeks of work could be destroyed in a moment through an error in the administration of punishment.

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[6] A habit is termed perfect when a chick successively makes 20 correct choices.

[7] The stimulus demanding a positive response is named first; following this is the stimulus demanding a negative reaction.

It was quite common for chicks that were being trained to go beyond the door to the nest box and crowd up to the stimulus at the end of the compartment. If the animal were allowed to do this it spent considerable time and energy trying to get through the illuminated stimulus plate. A thin plate of glass was placed across each compartment at a point just beyond the exit. The chicks could thus see through the stop but could not go beyond it. They thus were stopped near the exit so that they might learn more readily how to escape. As soon as they had acquired a mode of escape and had ceased trying to reach the stimulus, the glass plates were removed.

After a perfect habit had been acquired the amount of difference between the two stimuli was decreased. When the ⊙ 28+—⊙ 7+ discrimination, for example, was perfect, the condition was changed to ⊙ 28+—⊙ 9+. The large circle was thus the standard which remained constant. The smaller circle was the variable, which, after each perfect reaction, was successively increased in size until the animal could no longer choose correctly. This limit of correct choices was thus accepted as the chick's threshold of difference.

Table 1, page 74, provides for a series of stimulus plates that will enable the experimenter to make the most satisfactory changes in the variable stimulus. The changes in diameter can well be as great as 5 mm. between ⊙ 7+—and ⊙ 12+ when used with a standard ⊙ 28+. Above ⊙ 12+ the diameter of the variable should be successively increased only by 1 mm. The set of plates with which I started included a group between ⊙ 19+ and ⊙ 28+ varying in diameter by 1 mm., but provided only a ⊙ 16 between ⊙ 12+ and ⊙ 19+. A similar scale was provided between ⊙ 50+ and ⊙ 63+ but there were no variables between ⊙ 28+ and ⊙ 50+. After a little preliminary work, however, I discovered that a different scale of variables was necessary, and in table 1 I present the sizes which my experience leads me to regard as essential. Unless he wishes to make a study of that particular problem, the experimenter, in using variables differing in diameter by only 1 mm., must be alert to see that the natural discrimination of his subjects is not improved by training.

During the experiments with the first group of chicks, I was seeking to get a method as much as to train the birds. I can

## RECORD SHEET.

**Subject** 9 **Date** 12/7/'11—1/2/'12 **Experiment** Form Perception

| Tests → <br> Series ↓ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | R | W | REMARKS<br>Average Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | l | r | l | r | l | r | l | r | l | r | | | |
| B | r | l | r | l | r | l | r | l | r | l | | | |
| 1 | r<br>E-29 | l<br>0-6 | r<br>E-59 | l<br>0-19 | r<br>E-125 | l<br>0-120 | r<br>E-56 | l<br>E-95 | r<br>E-65 | l<br>0-44 | 4 | 6 | 61.8" |
| 2 | l<br>0-4 | l<br>0-24 | r<br>0-36 | r<br>0-30 | l<br>E-1-62 | r<br>0-39 | l<br>0-19 | l<br>E-2-180 | r<br>0-15 | r<br>0-33 | 8 | 2 | 44.2 |
| 3 | r<br>0-67 | r<br>0-8 | l<br>E-135 | r<br>0-28 | l<br>0-25 | l<br>E-2-141 | r<br>E-1-180 | l<br>E-1-21 | r<br>0-5 | l<br>E-1-61 | 5 | 5 | 67.1 |
| 4 | l<br>0-29 | l<br>E-1-42 | l<br>E-1-35 | r<br>0-55 | r<br>0-40 | r<br>0-64 | l<br>E-2-100 | r<br>0-30 | r<br>0-32 | l<br>E-1-65 | 6 | 4 | 49.2 |
| 5 | r<br>E-2-84 | l<br>0-8 | r<br>0-9 | l<br>0-12 | r<br>0-10 | l<br>0 6 | r<br>0-18 | l<br>0-26 | r<br>E-1-43 | l<br>E-2-38 | 7 | 3 | 25.4 |
| 6 | l<br>0-11 | l<br>0-14 | r<br>E-2-71 | l<br>0-21 | r<br>0-83 | r<br>E-2-41 | l<br>0-28 | r<br>E-2-110 | l<br>0-49 | r<br>E-2-118 | 6 | 4 | 54.6 |
| 7 | r<br>0-48 | l<br>0-31 | l<br>E-2-70 | l<br>0-7 | r<br>E-1-8 | r<br>E-1-23 | r<br>0-25 | l<br>0-6 | r<br>0-9 | l<br>E-1-56 | 6 | 4 | 28.3 |
| 8 | r<br>E-2-46 | r<br>0-62 | l<br>0-89 | l<br>0-67 | r<br>E-2-71 | l<br>0-58 | r<br>E-1-65 | l<br>E-1-56 | r<br>0-24 | l<br>E-1-29 | 4 | 6 | 56.0 |
| 9 | r<br>0-4 | r<br>0-5 | r<br>0-6 | l<br>E-1-20 | l<br>E-1-7 | l<br>0-21 | r<br>E-2-42 | l<br>E-1-23 | r<br>0-15 | l<br>E-1-16 | 5 | 5 | 15.9 |
| 10 | l<br>0-4 | l<br>0-9 | l<br>0-5 | l<br>0-31 | r<br>0-106 | r<br>0-19 | r<br>0-61 | r<br>0-5 | l<br>0-10 | r<br>0-45 | 10 | 0 | 29.5 |
| 11 | r<br>0-10 | l<br>E-2-124 | r<br>E-2-128 | r<br>0-35 | r<br>E-2-75 | l<br>0-67 | l<br>0-34 | l<br>0-26 | r<br>0-38 | l<br>E-1-88 | 6 | 4 | 60.2 |
| 12 | r<br>0-6 | l<br>0-37 | r<br>0-22 | l<br>0-10 | r<br>0-14 | r<br>0-12 | l<br>0-8 | l<br>0-8 | r<br>E-1-36 | l<br>E-1-14 | 8 | 2 | 16.7 |
| 13 | r<br>0-8 | l<br>0-7 | r<br>0-40 | l<br>0-45 | l<br>E-1-110 | l<br>0-3 | r<br>0-1-29 | r<br>E-1-20 | r<br>0-21 | l<br>E-2-44 | 7 | 3 | 32.7 |
| 14 | l<br>0-12 | l<br>E-1-123 | l<br>E-1-31 | l<br>0-10 | r<br>E-1-10 | r<br>0-74 | r<br>0-12 | r<br>E-1-27 | l<br>0-8 | r<br>E-1-31 | 5 | 5 | 33.8 |
| 15 | r<br>0-38 | l<br>0-11 | r<br>0-22 | r<br>0-8 | r<br>E-1-38 | l<br>E-2-54 | l<br>E-2-64 | l<br>0-16 | r<br>E 1-39 | l<br>0-5 | 6 | 4 | 29.5 |
| 16 | l<br>0-18 | r<br>0-8 | l<br>0-21 | l<br>0-30 | l<br>0-5 | r<br>E-1-46 | r<br>E-1-42 | r<br>0-33 | l<br>0-11 | r<br>0-28 | 8 | 2 | 24.2 |
| 17 | r<br>0-42 | r<br>0-37 | r<br>0-40 | r<br>0-11 | l<br>E-1-19 | l<br>E-1-50 | l<br>0-62 | l<br>0-30 | r<br>0-28 | l<br>E-1-19 | 7 | 3 | 42.8 |
| 18 | l<br>E-1-60 | r<br>E-1-94 | l<br>0-25 | r<br>E-1 35 | r<br>0-20 | l<br>E-1-24 | l<br>E-1-25 | r<br>0-15 | l<br>E-1-18 | r<br>0-12 | 4 | 6 | 32.8 |
| 19 | r<br>0-92 | l<br>0-40 | r<br>E-1-46 | l<br>E-1-76 | r<br>0-26 | l<br>E-1-59 | r<br>E 2-45 | l<br>0-10 | r<br>E-2-27 | l<br>E-1-33 | 4 | 6 | 44.7 |
| 20 | l<br>E-1-12 | l<br>0-39 | l<br>0-8 | r<br>E-2-17 | l<br>0-18 | r<br>0-25 | l<br>0-9 | r<br>E-1-60 | r<br>0-42 | r<br>E-1-103 | 6 | 4 | 33.3 |
| 21 | r<br>E-1-22 | l<br>0-12 | l<br>0-13 | r<br>E-1-15 | r<br>0-17 | l<br>E-1-26 | l<br>0-11 | r<br>E-2-10 | r<br>0-19 | l<br>E 1-40 | 5 | 5 | 18.5 |
| 22 | l<br>E-1-63 | l<br>0-19 | r<br>E-1-40 | r<br>E-1-20 | l<br>0-7 | l<br>0-21 | r<br>E-1-22 | r<br>E-2-30 | l<br>E-1-46 | r<br>E-1-25 | 3 | 7 | 29.3 |
| 23 | r<br>0-12 | l<br>0-25 | l<br>0-10 | l<br>0-8 | l<br>0-4 | r<br>E-2-41 | r<br>E-1-9 | r<br>0-2 | r<br>E-1-10 | l<br>E-1-12 | 6 | 4 | 13.3 |
| 24 | l<br>0-5 | r<br>E-1-49 | l<br>E-1-6 | l<br>0-3 | l<br>0-5 | r<br>0-4 | r<br>0-4 | r<br>0-4 | l<br>0-2 | r<br>E-1-45 | 7 | 3 | 12.7 |
| 25 | r<br>0-14 | r<br>0-12 | r<br>E-1-6 | r<br>0-26 | l<br>0-25 | l<br>0-23 | l<br>0-18 | l<br>0-15 | r<br>0-55 | l<br>0-25 | 9 | 1 | 27.8 |

not here attempt to show how the method was developed. Only its final form can be presented. A form of *record sheet* had previously been used in the laboratory for tabulating experimental results in the discrimination method. This blank was well suited to my needs. It provides spaces at the top for recording the name or number of the subject, the date, and the experiment. Across the sheet are 10 vertical columns in which may be entered the result of each test. Each group of 10 tests constitutes a series. The sheet provides for records of 25 series with a space for two (A and B) preliminary or preference series. The result of 250 tests, therefore, may be put on one record sheet. The vertical columns headed *R* and *W* are for the total number of *right* and *wrong* choices made by the subject during a series of 10 tests. Another vertical column leaves space for remarks.

This record sheet does very well for keeping a concise summary of the experiments, but it does not enable one to keep

TEST SHEET

Title of investigation, Form: ⊙ 28+—△ 28+
Experimented on, 9
Harvard Psychological Laboratory, December 25, 1912
Record Sheet, 1; Series, 15

| Test | Behavior | Record |
|---|---|---|
| 1 r | $/\overline{/}$ − /// + /// *u* | O–38 |
| 2 l | /// + /// *u* | O–11 |
| 3 r | $\overline{//}$ + /// *u* | O–22 |
| 4 r | // + // *u* | O–8 |
| 5 r | /// − // $\triangle^1$ + /// *u* | E–1–38 |
| 6 l | /// − /// $\triangle^2$ + // *u* | E–2–54 |
| 7 l | // − /// $\triangle^2$ + /// *u* | E–2–64 |
| 8 l | // + // *u* | O–16 |
| 9 r | // + / $\triangle^1$ + // *u* | E–1–39 |
| 10 l | / + // *u* | O–5 |

6–4–29.5

**Remarks**:—Tendency to choose by position,—*i.e.*, to go where it last escaped. Usually goes directly to other compartment when it has been shocked for wrong choice.

the details of the behavior. To do this I had a form of *test sheet* printed. It is headed by spaces for the title of investigation, the name of the subject, and the date; also there are spaces for reference to the *record sheet* and the particular series of the *record sheet* which the *test sheet* contains. The 10 tests, (horizontally arranged on the record page), appear vertically on the test page. After each one is a space for recording the details of the animal's behavior. At the right of the page is a narrow column for recording the results of the test,—whether or not an error was made, and the time for choosing. At the bottom is a space for remarks, where the record is always totalled and averaged,—total number of right and wrong choices and average of time in seconds. The record and this part of the remarks are transferred to their proper spaces in the record sheet.

The manner of recording the chick's behavior is illustrated in the accompanying *test sheet* which is a record of an actual series of tests. I used a set of symbols which enabled me to follow fairly accurately the movements of an animal while in the discrimination chamber. Herewith is presented the key to the symbols used in these experiments:

1. $+$ = Approach to *right* compartment.
2. $-$ = Approach to *wrong* compartment.
3. $/$, $//$, $///$ = Degree of attention based on behavior and time. A horizontal bar above any one of these symbols indicates unusually long time in this locality. For example,
    - a. $+/$ = Brief consideration of *right* stimulus area.
      $-/$ = Brief consideration of *wrong* stimulus area.
    - b. $+//$ = Longer consideration of *right* stimulus area.
      $-//$ = Longer consideration of *wrong* stimulus area.
    - c. $+///$ = Close consideration of *right* stimulus area.
      $-///$ = Close consideration of *wrong* stimulus area.
    - d. $+\overline{///}$ = Long time before and close consideration of *right* stimulus area.
      $-\overline{///}$ = Long time before and close consideration of *wrong* stimulus area.
    - e. $+\overline{/}$ = Long time before but slight consideration of *right* stimulus area.
      $-\overline{/}$ = Long time before but slight consideration of *wrong* stimulus area.
4. $\overline{\prime\prime\prime\prime\prime\prime\prime\prime\prime\prime\prime\prime\prime\prime\prime\prime}$ = Attention at entrance end; indifferent to stimulus areas.
5. $\wedge$ = Approach on wires before *right* stimulus followed by retreat.
6. $\vee$ = Approach on wires before *right* stimulus followed by wrong turn.
7. $\triangle$ = Approach on wires before *wrong* stimulus followed by retreat.
    - a. $\triangle^1$ = One shock.
    - b. $\triangle^2$ = Multiple shock.
    - c. $\triangle^0$ = No shock.
8. $\underset{\frown}{\bigcirc}$ = Turn around, right to left; $\overset{\smile}{\bigcirc}$, left to right.

9. ∾ = Partial turn around, right to left; ∽, left to right.
10. ⟍⟍ = Position directly before division between each compartment; by turning head either stimulus area is visible.
11. „ = Escape to nest box.
12. E = Error in choosing; this is followed by time in seconds.
13. O = Correct choice; this is followed by time in seconds.

The preliminary series were begun during the second week, usually when the chicks were 10 days old. The experiments were always conducted during the forenoon between the hours of eight and twelve. I believe the best results would be obtained from chicks if the work were begun earlier than eight. Chickens naturally start out early in the morning for their food. That is the time when they are most active. My observations do not wholly agree with Breed's conclusion that "hunger did not play a more important part than the reaction to confinement and solitude."[8] My best results came when I took the chick early in the morning and allowed it to earn its breakfast. The chick from which I received the best results reached the stage where it apparently took pleasure in the experiments. When I placed it in the apparatus it regularly began to give the characteristic "food twitter." This twittering was continued all of the time the bird was choosing and after it had escaped to the nest box where I was careful always to have a little food.

In the matter of rewarding with food, however, great care is necessary. A three-weeks-old chick will "fill up" in a very short time and then experimental work is difficult. I was careful to have only a few grains scattered in the litter of the nest boxes so that the chick had to work to find them. After getting this plan somewhat perfected I found that a chick could be given as high as 50 trials with no more difficulty than was previously common in 20 trials.

Until the chicks were five or six weeks old it was found best to give them no more than one series daily. After they reached this age the number of tests could be increased without harmful results. The subjects had usually learned to solve their problems by this time so that they expended much less energy than they did during the earlier tests. Moreover, the experimenter had an opportunity to select from his group the most promising subjects to which he could devote more time.

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[8] *Behavior Monographs*, vol. 1, no. 1, S. N. 1, p. 47.

### *4. Importance of method*

In the preceding section I have discussed in considerable detail the method and technique of my experiments. I do this because I believe an accurate solution of an animal problem depends upon the adoption of a favorable method. It is one of the greatest tasks that confronts the experimenter. He must use an apparatus by means of which he can accurately control the conditions of his study. He must also show alertness by controlling these conditions in such a way that his animals behave normally. Much animal stupidity, so-called, is really a reflection of human ignorance. Experimenters frequently lack animal intelligence by setting human problems for an animal to solve.

An animal frequently shows ingenuity in an unexpected direction, and if the experimenter be not alert he misses the most important part of the behavior. How many times this is the case, we cannot tell, for we only know of the cases where we did not miss the significant fact. A perfect method would make it impossible for the animal to pick up cues that were not intentionally offered by the experimenter. But it is through experience that we approach a perfect method for there is always the possibility of finding defects even in the best methods.

The importance of method was impressed upon me very forcibly through an incident in my experiments with the first group of chicks. I had inexcusably blundered by making the original conditions of discrimination too difficult for the birds. They were being tested on ⊙ 28+—⊙ 7+ discrimination. The subjects were allowed to go through the discrimination chamber and experiment box during the preliminary tests without regard to the position of the right or wrong stimulus; that is, both exits were open. When the training series were begun the brightness of the two stimuli were made markedly unequal and were irregularly varied *from the first.*

The experiment was begun with six subjects. As a partial result of my initial bungling, I had, at the end of a few days, only subjects 2 and 3 in suitable condition for experimental work. At the end of two and one-half weeks No. 2 gave up, but No. 3 persisted. At the end of the 24th series it had successively made three perfect series (see table 2). At the end of four more series it had reacted perfectly to the ⊙ 28+—⊙ 9+

discrimination. The variable was continually increased by 5 mm. (diameter) until the condition ⊙ 28+—⊙ 19+ was reached

TABLE 2

SUBJECT: 3. HATCHED: 10/3?/'11. SEX: UNDETERMINED

| Series* | Date | Right | Wrong | Time† |
|---|---|---|---|---|
| | ⊙ 28+—⊙ 7+ *Discrimination* | | | |
| 1–21 (1–21) | Oct. 12–27 | .. | .. | .. |
| 22 (22) | " 28 | 10 | 0 | 55 |
| 23 (23) | " 30 | 10 | 0 | 41 |
| 24 (24) | " 30 | 10 | 0 | 29 |
| | ⊙ 28+—⊙ 9+ *Discrimination* | | | |
| 1 (1) | Oct. 30 | 10 | 0 | 62 |
| 2 (2) | " 31 | 9 | 1 | 79 |
| 3 (3) | " 31 | 10 | 0 | 103 |
| 4 (4) | Nov. 1 | 10 | 0 | 55 |
| | ⊙ 28+—⊙ 12+ *Discrimination* | | | |
| 1 (6) | Nov. 2 | 7 | 3 | 71 |
| 2 (7) | " 3 | 9 | 1 | 93 |
| 3 (8) | " 3 | 10 | 0 | 50 |
| 4 (9) | " 4 | 10 | 0 | 52 |
| | ⊙ 28+—⊙ 15+ *Discrimination* | | | |
| 1 (11) | Nov. 4 | 6 | 4 | 112 |
| 2 (12) | " 6 | 9 | 1 | 68 |
| 3 (13) | " 6 | 8 | 2 | 44 |
| 4 (14) | " 6 | 8 | 2 | 51 |
| 5 (15) | " 7 | 9 | 1 | 52 |
| 6 (16) | " 7 | 9 | 1 | 40 |
| 7 (17) | " 7 | 8 | 2 | 41 |
| 8 (18) | " 8 | 10 | 0 | 52 |
| 9 (19) | " 8 | 10 | 0 | 62 |
| | ⊙ 28+—⊙ 19+ *Discrimination* | | | |
| 1 (21) | Nov. 8 | 8 | 2 | 49 |
| 2 (22) | " 9 | 8 | 2 | 49 |
| 3 (23) | " 9 | 8 | 2 | 90 |
| 4 (24) | " 9 | 10 | 0 | 50 |
| 5 (25) | " 10 | 8 | 2 | 78 |
| 6 (26) | " 10 | 10 | 0 | 53 |
| 7 (27) | " 11 | 10 | 0 | 47 |
| | ⊙ 28+—⊙ 23+ *Discrimination* | | | |
| 1 (6) | Nov. 11 | 8 | 2 | 58 |
| 2 (7) | " 13 | 8 | 2 | 116 |
| 3 (8) | " 14 | 10 | 0 | 41 |
| 4 (9) | " 15 | 8 | 2 | 45 |
| 5 (10) | " 15 | 10 | 0 | 16 |

* Numbers in parentheses refer to series on record sheet.

† Average time for series given in seconds.

TABLE 2—*Continued*

SUBJECT: 3. HATCHED: 10/3?/'11. SEX: UNDETERMINED

| Series* | Date | Right | Wrong | Time† |
|---|---|---|---|---|
| | ⊙ 28+—⊙ 24+ *Discrimination* | | | |
| 1 (21) | Nov. 17 | 10 | 0 | 22 |
| 2 (22) | " 17 | 9 | 1 | 30 |
| 3 (23) | " 18 | 10 | 0 | 16 |
| 4 (24) | " 18 | 10 | 0 | 11 |
| | ⊙ 28+—⊙ 25+ *Discrimination* | | | |
| 1 (11) | Nov. 21 | 9 | 1 | 22 |
| 2 (12) | " 21 | 10 | 0 | 16 |
| 3 (13) | " 21 | 9 | 1 | 17 |
| | ⊙ 28+—⊙ 26+ *Discrimination* | | | |
| 1 (16) | Nov. 22 | 10 | 0 | 15 |
| 2 (17) | " 22 | 9 | 1 | 24 |
| 3 (18) | " 23 | 7 | 3 | 45 |
| 4 (19) | " 23 | 10 | 0 | 23 |
| | ⊙ 28+—⊙ 27+ *Discrimination* | | | |
| 1 (21) | Nov. 23 | 8 | 2 | 20 |
| 2 (22) | " 23 | 8 | 2 | 25 |
| 3 (23) | " 24 | 6 | 4 | 33 |
| 4 (24) | " 24 | 10 | 0 | 11 |
| 5 (25) | " 24 | 9 | 1 | 30 |
| | ⊙ 28+—⊙ 28+ *Discrimination* | | | |
| 1 (1) | Nov. 25 | 10 | 0 | ? |
| 2 (2) | " 25 | 6 (crack closed) | 4 | ? |
| 3 (3) | " 25 | 0 | 5 | ? |
| | ⊙ 28+—⊙ 23+ *Discrimination* | | | |
| 1 (16) | Nov. 27 | 5 | 5 | 62 |
| 2 (17) | " 27 | 5 | 5 | 59 |
| | ⊙ 28+—⊙ 19+ *Discrimination* | | | |
| 1 (18) | Nov. 28 | 3 | 7 | 71 |
| | ⊙ 28+—⊙ 15+ *Discrimination* | | | |
| 1 (19) | Nov. 28 | 9 | 1 | 60 |
| | ⊙ 28+—⊙ 19+ *Discrimination* | | | |
| 1 (20) | Nov. 29 | 6 | 4 | 73 |
| 2 (21) | " 29 | 5 | 5 | 83 |
| 3 (22) | " 30 | 7 | 3 | 31 |
| 4 (23) | " 30 | 7 | 3 | 22 |
| 5 (24) | " 30 | 5 | 5 | 23 |
| 6 (25) | Dec. 1 | 5 | 5 | 27 |

* Numbers in parentheses refer to series on record sheet.
† Average time for series given in seconds.

after which the diameter of the variable was changed by increments of 1 mm. The perfect responses continued almost as regularly as the variable was increased. Finally the behavior of the chick indicated that it was discriminating between ⊙ 28+ and ⊙ 27+ (see record of November 23 and 24).

A ⊙ 28+—⊙ 27+ discrimination was incredible, for the human eye could scarcely detect a difference between a 28+ sq. cm. circle and a 23+ sq. cm. circle. The only thing to do was to test the chick on ⊙ 28+—⊙ 28+ discrimination. The result was a perfect series. (See record 1, November 25.) Then I began to look for the cue on which the chick relied. At last I noticed a small crack where the outside extension of the electric box was joined to the experiment box. A similar crack appeared on both sides in corresponding positions, hence it seemed that in this factor there could be no clue by means of which the chick was guided in its choice of the *right* compartment.

Close inspection, however, proved that in these two minute cracks lay the cue by means of which the chick had been discriminating. Where the rabbeted edges of the shifter and tracks rubbed, there was a bright edge, and wherever the shifter rested, this bright surface was covered. Thus when the shifter was at the left, the right end of the track was uncovered, and from this uncovered part was reflected some of the light rays from the upper illumination. A small portion of this reflected light could enter the crack on the left side. Now, when the standard circle was presented at the left, it happened that the shifter was moved to the right; when the standard appeared at the right, the shifter stood at the left. As a result, the crack that was illuminated was always the one where the standard circle was displayed; the other crack, being reached by no reflected light, was always dark.

Noticing this *slight* variation in the condition of illumination in the two compartments, and desiring to ascertain by what clue the chick was choosing, I closed the small cracks through which the light was reflected. The effect of this change appears in the records following the first on November 25. The perfect reactions abruptly stopped with the closing of the cracks; out of 15 tests there were only six correct responses. As appears in the subsequent part of table 2, I continued the experiment, *with the cracks stopped*, by reducing the area of the variable to

23+, (November 27), then to 19+ and finally to 15+ before the chick again began to react correctly to the stimuli. When the ⊙ 28+—⊙ 19+ discrimination was again presented, the subject was able to choose correctly in little more than half of the tests. The physical condition of No. 3 on December 1 made it necessary to abandon further work. Up to that date it had appeared in all respects normal, but the final series was conducted with great difficulty on account of the common "leg-weakness" which had suddenly developed. With the appearance of this disease, the experiment was abruptly closed.

The chick, then, had detected a faint streak of light, not more than 6 mm. long and less than 1 mm. wide,—an illumination so small that not only I but others who were working in the laboratory had quite overlooked it. By considering the amount of light that came from the upper illumination, the poor reflecting surface of a steel strap worn only moderately bright, and the narrow surface from which the light was reflected, (not more than 1 cm. in width), the reader can judge how insignificant this strip of light would appear. It was clearly a case of the chick "outguessing" the experimenter.

## III. SIZE PERCEPTION

### *1. Discrimination between unequal circles*

The foregoing discussion of method suggests the nature of the difficulties which were encountered in the early experimental work. No trustworthy results were secured until after the crack of light was discovered. By this time No. 3 was the only subject of the first group that was still working. The later experiments with this chick indicated that the early discrimination had been made on the basis of size difference, but as the variable became larger and the discrimination correspondingly harder, No. 3 began to look for other cues and happened upon the one which has been described.

A glance at table 2 suggests the point where No. 3 ceased to discriminate between the two size stimuli. After the control tests, ⊙ 28+—⊙ 28+ discrimination, during which the crack was stopped, the chick's response to ⊙ 28+—⊙ 23+ was tested. The results were decidedly negative since the *right* stimulus was chosen no more than chance would allow. The response to

⊙ 28+—⊙ 19+, having only three right choices, was even more negative, but when the ⊙ 28+—⊙ 15+ discrimination was tested, the results were clearly positive. The standard was chosen nine times and the variable was chosen only once. Here is probably the place where, in the earlier training, the new cue first figured. While the average results of the tests with the ⊙ 19+ variable are slightly in favor of the larger stimulus, I believe the fact should not be emphasized, for the larger circle was chosen in 60 trials only five more times than would have occurred had chance alone determined the choices.

Table 3 summarizes the results of my investigation on the chick's perception of size. In some cases the results are not so clear cut as one might wish, but this fact is due to the uncertainty of health among the birds which made it advisable to hurry the tests, without waiting in some cases for the acquisition of perfect habits, in order to take the chicks to their limit in discrimination.

By considering not only the right-wrong records but also the peculiarities in behavior which cannot be presented in tabular form, I am convinced that the largest variable the chick can distinguish, under the conditions here described, from a standard ⊙ 28+ lies somewhat above ⊙ 15+. The quantitative measurements on the basis of right choices points strongly to this conclusion. Every subject, excepting 7 and 20, succeeded in making at least 88% of correct choices in a series when the ⊙ 28+—⊙ 15+ discrimination was required. Even in the case of the two exceptions, 7 and 20, an efficiency of 70% was acquired. But more convincing still is the fact that two chicks, 3 and 17, reached 90%, and two, 16 and 21, made perfect series.

The time used in choosing is a factor which offers a means of measuring quantitatively the chick's threshold of discrimination. It should not be unduly emphasized for it is not wholly reliable, yet in these experiments it tends to substantiate the conclusion which has been based upon the percentage of right choices. Since the animal is less acquainted with the conditions during the ⊙ 28+—⊙ 7+ discrimination as compared with the ⊙ 28+—⊙ 15+ discrimination, it would be expected, other things remaining constant, to choose more readily during the later tests. Furthermore, the increase in age and activity should enable it to choose more rapidly during the later tests.

## TABLE 3

### Discrimination Between Unequal Circles

| Series | No. 3[1] | | | | | | No. 6♂ | | | | | | No. 7♂ | | | | | | No. 15♂[2] | | | | | | No. 16♂[2] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 28+ 7+ | | 28+ 12+ | | 28+ 15+ | | 28+ 7+ | | 28+ 12+ | | 28+ 15+ | | 28+ 7+ | | 28+ 12+ | | 28+ 15+ | | 28+ 7+ | | 28+ 12+ | | 28+ 15+ | | 28+ 7+ | | 28+ 12+ | | 28+ 15+ | |
| | R | W | R | W | R | W | R | W | R | W | R | W | R | W | R | W | R | W | R | W | R | W | R | W | R | W | R | W | R | W |
| 1..... | | | 5 | 5 | 9 | 1 | 7 | 3 | 8 | 2 | 8 | 2 | 8 | 2 | 10 | 0 | 7 | 3 | 9 | 1 | 10 | 0 | 7 | 3 | 9 | 1 | 8 | 2 | 10 | 0 |
| 2..... | | | 8 | 2 | [3] | | 9 | 1 | 8 | 2 | [4] | | 6 | 4 | 9 | 1 | 7 | 3 | | | | | 7 | 3 | | | | | | |
| 3..... | | | 6 | 4 | | | 9 | 1 | 8 | 2 | | | 7 | 3 | 7 | 3 | [4] | | | | | | 8 | 2 | | | | | | |
| 4..... | | | 8 | 2 | | | 8 | 2 | 6 | 4 | | | 9 | 1 | 8 | 2 | | | | | | | | | | | | | | |
| 5..... | | | 9 | 1 | | | 10 | 0 | 8 | 2 | | | 9 | 1 | 9 | 1 | | | | | | | | | | | | | | |
| 6..... | | | 6 | 4 | | | 9 | 1 | 6 | 4 | | | 9 | 1 | 8 | 2 | | | | | | | | | | | | | | |
| 7..... | | | 10 | 0 | | | 8 | 2 | 8 | 2 | | | 10 | 0 | | | | | | | | | | | | | | | | |
| 8..... | | | | | | | 6 | 4 | | | | | 8 | 2 | | | | | | | | | | | | | | | | |
| 9..... | | | | | | | 9 | 1 | | | | | 10 | 0 | | | | | | | | | | | | | | | | |
| 10..... | | | | | | | 10 | 0 | | | | | 10 | 0 | | | | | | | | | | | | | | | | |
| 11..... | | | | | | | 8 | 2 | | | | | 10 | 0 | | | | | | | | | | | | | | | | |
| 12..... | | | | | | | 10 | 0 | | | | | 10 | 0 | | | | | | | | | | | | | | | | |
| 13..... | | | | | | | 10 | 0 | | | | | 10 | 0 | | | | | | | | | | | | | | | | |

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[1] Preceded by tests which were ruled out on account of the crack of light.

[2] The record for ⊙ 28+—⊙ 7+ was preceded by 13 series in which the light factors were combined; the record given represents the first series after all factors except size were eliminated.

[3] Followed by ⊙ 28+—⊙ 19+ in which No. 3 failed.

[4] Tests were hurried on account of physical condition of subject.

## TABLE 3—*Continued*

### DISCRIMINATION BETWEEN UNEQUAL CIRCLES

| Series | No. 17♀[2] | | | | | | No. 18♂[2] | | | | | | No. 20♂(?)[2] | | | | | | No. 21♀[2] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 28+ 7+ | | 28+ 12+ | | 28+ 15+ | | 28+ 7+ | | 28+ 12+ | | 28+ 15+ | | 28+ 7+ | | 28+ 12+ | | 28+ 15+ | | 28+ 7+ | | 28+ 12+ | | 28+ 15+ | |
| | R | W | R | W | R | W | R | W | R | W | R | W | R | W | R | W | R | W | R | W | R | W | R | W |
| 1 | 10 | 0 | 10 | 0 | 8 | 2 | 8 | 2 | 10 | 0 | 8 | 2 | 9 | 1 | 8 | 2 | 7 | 3 | 7 | 3 | 10 | 0 | 10 | 0 |
| 2 | | | | | 9 | 1 | | | | | 5 | 5 | | | | | 7 | 3 | | | | | 7 | 3 |
| 3 | | | | | | | | | | | 8 | 2 | | | | | [6] | | | | | | 8 | 2 |
| 4 | | | | | | | | | | | [5] | | | | | | | | | | | | 8 | 2 |
| 5 | | | | | | | | | | | | | | | | | | | | | | | 6 | 4 |
| 6 | | | | | | | | | | | | | | | | | | | | | | | 10 | 0 |
| 7 | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | | | | | | | | |

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[2] The record for ⊙ 28+—⊙ 7+ was preceded by 13 series in which the light factors were combined; the record given represents the first series after all factors except size were eliminated.

[5] Became discouraged.

[6] Tests ended on account of physical condition of subject.

Table 4, however, shows that this was not the case. The total average in seconds of time for ⊙ 28+—⊙ 7+ was 11. This time was increased for ⊙ 28+—⊙ 12+ to 16, and for ⊙ 28+—⊙ 15+ to 20 seconds.

TABLE 4

AVERAGE TIME FOR CHOOSING

| Subject | ⊙ 28+—⊙ 7+ | ⊙ 28+—⊙ 12+ | ⊙ 28+—⊙ 15+ |
|---|---|---|---|
| 6 | 15″ | 13″ | 7″ |
| 7 | 22 | 59 | 55 |
| 15 | 8 | 5 | 31 |
| 16 | 30 | 28 | 11 |
| 17 | 3 | 8 | 13 |
| 18 | 4 | 3 | 20 |
| 20 | 3 | 13 | 11 |
| 21 | 6 | 2 | 9 |
| Average | 11 | 16 | 20 |

It might be urged that this time average changed during the course of the experiments on account of the physical condition of the chicks. I do not believe this was the cause. Consider the record made by No. 21. This chick was one of the few which was turned out of doors, where its physical condition improved. That it was not weak at the conclusion of the work on size discrimination is suggested by the fact that it was put through nearly 1500 subsequent tests on form vision. This chick, as shown in table 3, made perfect records in ⊙ 28+—⊙ 15+ discrimination. Its time, according to table 4, averaged six seconds during the ⊙ 28+—⊙ 7+ tests, only two seconds in the ⊙ 28+—⊙ 12+ test, and nine seconds in the ⊙ 28+—⊙ 15+ tests. Evidently the chick was slower in the ⊙ 28+—⊙ 7+ tests where it was learning, its time was *not* increased when the variable was increased to ⊙ 12+ because the discrimination was still easy, but the time *was* increased when the more difficult discrimination, ⊙ 28+—⊙ 15+, was required.

The detailed behavior of the birds, furthermore, tends more firmly to establish the explanation offered. To illustrate how the behavior differed under the conditions of *easy* and *difficult* discrimination, two test sheets are presented.

## TEST SHEET 1

Title of investigation, Size: ⊙ 28+—⊙ 7+
Experimented on, 21
Harvard Psychological Laboratory, February 28, 1912
Record Sheet, 1. Series, 6

| Test | Behavior | Record |
|---|---|---|
| 1 l | // + /// ″ | 0–4 |
| 2 l | + $\overline{///}$ ″ | 0–5 |
| 3 r | + $\overline{///}$ ″ | 0–2 |
| 4 l | + $\overline{///}$ ″ | 0–1 |
| 5 r | + $\overline{///}$ ″ | 0–2 |
| 6 r | + $\overline{///}$ ″ | 0–2 |
| 7 l | + $\overline{///}$ ″ | 0–2 |
| 8 r | + $\overline{///}$ ″ | 0–2 |
| 9 l | + $\overline{///}$ ″ | 0–2 |
| 10 r | + $\overline{//}\,\overline{'''''''}$ ″ | 0–10 |

10–0–3.2

Test sheet 1 shows that No. 21 lost no time on entering the discrimination chamber, but went *directly* in every case to the correct stimulus where it entered the electric compartment and escaped to the nest box. Its final record in this series was 10 correct and no wrong choices, with an average time of 3.2 seconds. Test sheet 2 shows a different condition. No. 16 was discriminating between ⊙ 28+ and ⊙ 12+. In the first test the chick was quiet for a long while on entering the discrimination box; then it went to the *wrong* side where it stopped momentarily about two-thirds of the distance between the back of the discrimination box and the beginning of the electric wires. It then turned to the left, went close to the left electric compartment, hesitated, and entered only to turn to the right and come out. After looking closely again at the *wrong* (right hand) stimulus it turned back to the *right* (left hand) compartment and escaped. The behavior was somewhat similar in the second test except that in turning away from the *wrong* stimulus which

### TEST SHEET 2

Title of investigation, Size: ⊙ 28+—⊙ 7+
Experimented on, 16
Harvard Psychological Laboratory, March 6, 1912
Record Sheet 1; Series 16

| Test | Behavior | Record |
|---|---|---|
| 1 l | $\overline{///} - // + /// \vee - \overline{///} + ///$ " | O–47 |
| 2 r | $/// - // \underset{\frown}{\bigcirc} + ///$ " | O–38 |
| 3 l | $\overline{///} + - + // - \overline{/\ \triangle^1} + - // \triangle^1 + //$ " | E–2–58 |
| 4 l | $// + \overline{///} \wedge \underset{\frown}{\bigcirc} - /// + ///$ " | O–35 |
| 5 l | $/// + ///$ " | O–11 |
| 6 r | $/// - \overline{//}\ //\ \triangle^1 + ///$ " | E–1–21 |
| 7 r | $// + /// - /// \underset{\frown}{\bigcirc} + ///$ " | O–22 |
| 8 r | $+ ///$ " | O–5 |
| 9 l | $+ /// \underset{\frown}{\overline{\bigcirc}} - /// \overset{\overline{\smile}}{\bigcirc} + ///$ " | O–35 |
| 10 r | $// + ///$ " | O–10 |
| | | |

8–2–28.2

this time was at the left, the chick turned itself completely around, counter clockwise, and came up to the *right* stimulus. The third test shows that No. 16 made two errors for each of which it was shocked. Test 9 indicates where the chick made two complete turns,—one counter clockwise from the *right* compartment which this time is at the left side, and one clockwise turn from the *wrong* or right hand compartment.

These two test sheets have been selected with an idea of showing as marked contrast as possible, that the reader may see how important is the chick's behavior during each test and series. The first shows that No. 21 had no difficulty in choosing the proper stimulus. The second indicates that No. 16 was comparing both stimuli and using considerable care in choosing, although it made two errors. The choice record would indicate poor discrimination, but the behavior shows that the bird was really discriminating. The time contrast also stands out in the two series. These two series cannot be called typical of my experiments, yet, on the whole, they fairly represent the principles of the chick's mode of discrimination.

On the basis of choices, behavior, and time, it thus appears that the chick's limit in discrimination from a standard ⊙ 28+ lies somewhere between ⊙ 15+ and ⊙ 19+. To express the relation in terms of centimeters instead of square centimeters, the size in diameter of the variable is above 4.5 but below 5, that of the standard is 6. *The threshold of difference with a standard 6, therefore, is one-fourth to one-sixth.*

### *2. Technique in experiments on size*

After working only a short time on size perception I was convinced that the chick which was being trained should be aided by having the differences between the two visual stimuli emphasized by a combination of light factors which would aid in the earlier discrimination. Two stimulus areas, differing from each other with respect to one quality only, present to the animal a problem which is quite unnatural. Under natural conditions it relies upon combinations of many visual factors. The perception of an isolated visual quality is a human problem, not an animal problem.

After a little preliminary sparring, therefore, the chick which was being trained was first presented with two stimuli differing from each other with respect to size, form, and brightness. The stimulus to be chosen was a triangle larger and brighter than a circle. On account of these conditions the *right* stimulus appeared in the lighter compartment. The chick was thus trained to choose (1) the lighter compartment in which the stimulus area was (2) larger, (3) triangular, and (4) brighter. The process now was to remove, if possible, so gradually that the chick was aware of no changes, all of the inequalities between the two stimuli except size difference. This was not difficult to do. As is indicated in table 3, undesired factors were removed before the 14th series, and the single record that is given in the table for ⊙ 28+—⊙ 7+ discrimination is the first one in which the conditions were so arranged that the chick could not possibly choose on the basis of any factor other than size. As the table also suggests this was the first and only ⊙ 28+—⊙ 7+ series of this sort; the next deals with ⊙ 28+—⊙ 12+ discrimination.

That the discrimination was not by some factor or factors other than size, an explanation of my method during the control tests will show. In the main, the same procedure, but a more crude form, was carried out with Nos. 3, 6, 7, for with them the control method was conducted less definitely from the beginning of the training.

TABLE 5

Control Series for ⊙ 28+—⊙ 7+ Discrimination
Nos. 15, 16, 17, 18, 20, and 21
March 4, 1912
Record Sheet 1. Series 14

| Test | Source distance from | | General illumination of | |
|---|---|---|---|---|
| | + Stimulus | — Stimulus | + Compartment | — Compartment |
| | cm. | cm. | | |
| 1 l | 240 | 125 | Uncontrolled except for upper illumination. | |
| 2 l | 240 | 125 | " | " |
| 3 r | 240 | 125 | Much darker: Covered with 2 thicknesses of ground glass. | Much lighter: Covered with thin sheet of plain glass. |
| 4 l | 240 | 125 | Darker: Covered with 1 thickness of ground glass. | Lighter: Covered with 1 thickness of plain glass. |
| 6 r | 240 | 240 | " | " |
| 7 l | 180 | 180 | " | " |
| 8 r | 180 | 180 | " | " |
| 9 l | 180 | 180 | " | " |
| 10 r | 180 | 180 | " | " |

The plan of the control is concisely stated in table 5. The location of the source lamps was varied according to the plan of the second and third columns. The illumination of the electric boxes was controlled according to the last two columns. In tests 1 and 2, the + or *right* stimulus area was considerably brighter and that compartment was markedly lighter than the other. In tests 3 and 4 the *right* stimulus was brighter but the general illumination was reversed. The *right* compartment was kept slightly darker after the fourth test than the *wrong* compartment. In this respect the conditions were exactly reversed from those of all former series, but the chicks had, in earlier series, become accustomed to reversal of brightness. It was under these conditions that the records of chicks 15, 18, 20, and 21, as presented in table 3, were made. It is incredible that the discriminations occurred on any basis other than size difference.

## IV. FORM PERCEPTION

### 1. *Literature*

On account of the contrast between the outcome of my study of the chick's discrimination of form differences and the results reported by earlier experimenters in the same field, it is desirable to preface the account of my experiment with a brief review of these preceding studies on form perception. I shall limit this review to a consideration of two papers; one by Katz and Révész[9] and the other by Breed.[10] In both papers positive results have been reported.

In its simpler form, the "Klebmethode" of Katz and Révész consists in pasting on a cardboard, kernels of grain at which the chicken's pecking response is to become inhibited. Among these "glued" kernels is scattered a different kind of grain which the bird is allowed to pick up. To illustrate, it was found by the experimenters that the birds preferred rice to wheat. Twenty kernels of rice were glued to the background and 10 grains of wheat were scattered among them. A series was recorded every time the chicken picked up the wheat. The bird was classed as "Fehlerfrei" when it had picked up the wheat without pecking at the rice. The observers had two quantitative measurements for the rapidity of learning: (1) The number of series necessary for a perfect reaction; (2) the number of reactions to rice. To make sure that the "errorless" birds did not avoid the rice by means of the glue which might be visible on the pasted kernels, the rice was scattered loosely upon the cardboard in the same manner as the wheat. The wheat was again eaten by the "errorless" birds and the rice was left. The discrimination, the authors concluded, was between wheat and rice.

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[9] Katz, D. and Révész, G. Experimentell-psychologische Untersuchungen mit Hühnern, *Zeit. f. Psych. u. Physiol. d. Sinnesorgane,* 1909, Bd. 50, P. 93.

[10] Breed, Frederick S. Reactions of chicks to optical stimuli, *Jour. Animal Behavior,* 1912, vol. 2, pp. 280-295.

Having found that the chicken could learn to pick up wheat and avoid rice, Katz and Révész sought to answer the question: By what means does the bird discriminate between the two kinds of grain? Accordingly they began to test the chicken's discrimination of sizes and forms. Because the chickens could be trained to eat only half-grains of rice when scattered among whole grains, the authors were convinced that there was a discrimination of size and form. A little further study leads them to conclude: "The chicken also discriminates between squares and triangles. Knowledge of this fact we secured through a variation of the experimental procedure. Out of green peas, (some of which had been readily eaten), we cut three and four cornered pieces. On account of their moisture they could not be glued down, so we laid the four sided-pieces upon a glass plate and the three-sided pieces under it. The chicken found that the three-sided pieces could not be reached and soon ceased to peck at them. Then if we laid both forms upon the glass plate, only the squares were picked up. By means of the same method we found that the chicken discriminates between triangles and circles as well as squares and triangles."

The study made by Katz and Révész is open to the same general objection with which this paper was opened. They have, in too many cases left the reader uncertain of the exact conditions. They have tried to do too much and have not accomplished any one task; their report indicates carelessness and indifference to details. Such work makes an interesting paper. It is probably received more favorably by the majority of readers than an intensive study of a problem. After all, however, this sort of superficial work does not get us anywhere. No doubt the statement that "the chicken also discriminates between squares and triangles" and "between triangles and circles as well as squares and circles," holds true for the conditions under which the experiment was made. But from the written account *one cannot tell what the conditions were.* One does not know, for example, the relative sizes of the different forms. Were they equal in area? Was the square an inscription of the circle or *vice versa?* Was the diameter of the circle equal to the height of the square or the altitude of the triangle? These are some of the factors which *must be known* before one can safely say that the chicken perceives form. One could truthfully state that an animal was discriminating between a circle and a triangle if it regularly chose the former even though the triangle were *seven* times as large as the circle, but it is quite improbable that the basis of discrimination in such a case would be anything other than size. Since such points were omitted from the written account, one suspects that the technique of the experimenters was decidedly imperfect. Even had they taken the precaution of equalizing the sizes, they would then have faced a problem still more difficult. Their task would then have been to show that the discrimination was not due to unequal stimulation of different parts of the retina. Furthermore, no information is offered as to the method of cutting these forms. It is a very difficult matter to cut green peas after any regular manner. How can the observers be certain that their subjects discriminated on the basis of form rather than irregularities in the surfaces? They make no mention of "check tests" to eliminate this possibility. It is because they leave vital points like these unmentioned and apparently unnoticed that one is led to class the experiment as a very superficial piece of work.

In the report by Breed on the reactions of chicks to form stimuli [11] the conditions of the experiment have been accurately presented. His chicks were given an opportunity to select a circle when appearing along with a square. Both stimuli were presented in a dark room by means of the illumination of screens consisting of two plates of flashed opal glass, over which were set mats of tin or cardboard containing the desired openings. Three chicks were used in this study, one of which, No. 76, "learned to discriminate two optical stimuli on the basis of difference of form."

Because his studies of the reaction of other chicks to similar stimuli yielded negative results, Breed attributes the positive reactions of No. 76 to a fortunate choice of subject. Unfortunately, however, he seems to have made no control tests to determine whether or not the distribution of light on the chick's retina was influential. An inversion of a square would cause no change in the distribution of light; such a change might have been produced by turning the square through 45°. A control test of this sort, however, is more easily made when a triangle is presented along with a circle. Inversion of a triangle produces a marked difference in the distributions of the light which reaches the retina, yet the form of the stimulus is unchanged.

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[11] *Op. cit.*, pp. 290-293.

In the following report of my own tests on form discrimination, it will be noticed that I obtained results as positive as those of Breed when the apex of the triangle was at the top. When the position of the triangle was inverted, however, the perfect reactions ceased. It was so difficult to get a chick to react positively when a square was used with a circle that I found it practicable to make the control test on the distribution of light only in the case of the circle-triangle reaction. It is regrettable that Breed failed to make this control test in his experiments.

### 2. *Experiments*

The development of my system in the study of the chick's form perception followed, in general, that which occurred in my study of reactions to sizes. Work on this visual factor, i.e., the discriminative ability between circles and triangles which are equal in area, was done with two of the second group of chicks, Nos. 9 and 11. The latter became afflicted with "weak legs" after the 24th series, up to which time it had given no positive results. The results from No. 9 might be regarded as slightly positive.

On the whole the results in table 6 show a preference for the circle. Series 10 was perfect. One contains 90% of *right* choices and several reached 70% or 80%. It is not surprising that the chick became discouraged, since I had not yet adopted the plan of beginning with complex stimuli and working toward the simple. A system of control similar to that described under size perception (p. 98) was used throughout the work. The surprising feature is the high percentage of right choices on January 4 and 5 when the chick was becoming discouraged and frightened. This condition resulted in a rush for one stimulus or the other as though "to get the choice over." It appears that there was some sort of a difference between the two illuminations which tended to catch the eye of the rushing chick, but this was not clearly enough perceived for a dependable basis of discrimination. Finally, this experiment did not definitely prove, even though we admit a preference for the circle,

TABLE 6

Form Perception: ⊙ 28+—△ 28+

No. 9. Hatched: December 1, 1911. Sex: ♀

| Series | Date | Right | Wrong | Time |
|---|---|---|---|---|
| 1 | Dec. 9 | 4 | 6 | .... |
| 2 | 11 | 8 | 2 | 44.2 |
| 3 | 12 | 5 | 5 | 47.1 |
| 4 | 13 | 6 | 4 | 49.2 |
| 5 | 14 | 7 | 3 | 24.8 |
| 6 | 15 | 6 | 4 | 54.6 |
| 7 | 16 | 6 | 4 | 28.3 |
| 8 | 18 | 4 | 6 | 56.8 |
| 9 | 19 | 5 | 5 | 15.9 |
| 10 | 19 | 10 | 0 | 29.5 |
| 11 | 20 | 6 | 4 | 60.2 |
| 12 | 21 | 8 | 2 | 16.7 |
| 13 | 22 | 7 | 3 | 42.7 |
| 14 | 23 | 5 | 5 | 32.8 |
| 15 | 25 | 6 | 4 | 29.5 |
| 16 | 26 | 8 | 2 | 24.2 |
| 17 | 27 | 7 | 3 | 42.8 |
| 18 | 27 | 4 | 6 | 32.8 |
| 19 | 28 | 4 | 6 | 44.7 |
| 20 | 28 | 6 | 4 | 33.2 |
| 21 | 28 | 5 | 5 | 22. |
| 22 | 29 | 3 | 7 | 29.3 |
| 23 | 29 | 6 | 4 | 13.3 |
| 24 | 30 | 7 | 3 | 12.7 |
| 25 | Jan. 2 | 9 | 1 | 27.8 |
| 1 | 2 | 7 | 3 | 30.9 |
| 2 | 3 | 5 | 5 | 25.4 |
| 3 | 4 | 7 | 3 | 12.5 |
| 4 | 5 | 8 | 2 | 4.6 (Rushing) |
| 5 | 6 | (Discouraged; rushed blindly to either stimulus.) | | |

that the chick perceived form. The preference may well have been due to the distribution of light or the unequal stimulation of different parts of the retina.

As has been earlier stated, the original plan was to test the minimum form difference a chick could perceive. The result of my investigation with No. 9 convinced me that it was necessary first to determine whether or not the chick perceives form. When the study of form perception was begun with group 3, the plan that was explained in the preceding chapter on size was adopted. That is, form, in the beginning, was made only one of other visual factors which were gradually eliminated as the experiment progressed. Only one chick, No. 21, gave anything like positive results. This bird, including 22 series on size and brightness vision, was given more than 1500 tests. The work done with it is the only experiment of value that was made on form perception.

The experiment on form discrimination with No. 21 may be divided into three parts: (1) A preliminary investigation; (2) reactions to the triangle-circle and (3) reaction to the circle-triangle. When the work on form perception was begun, I had learned how to get much more work out of my subject and, at the same time, less energy was called forth than in the earlier tests. No. 21 knew me quite well by this time. It was perfectly contented to leave the other birds in the chick-room and go alone with me to the dark-room for work. The chief reason for this was the fact that it always had its morning meal in the dark-room. As soon as we reached the experiment room it was fed a little chick food and allowed to run freely about until the apparatus was made ready for the tests. While I was preparing the apparatus, the chick would follow me about the room (then lighted) twittering and contented, but if I left it alone for a few minutes its dissatisfaction was made known by loud and persistent peeping.

When everything was ready the chick was placed in the apparatus. At this point the note in its voice changed very noticeably. I cannot describe this sound, except that it was a slightly modified, I believe it might be called a *modulated*, "hovering twitter." Very commonly this peculiar sort of singing changed as the bird entered the discrimination chamber, to the "food twitter" which was continued all the time it was inspecting and comparing the two stimulus areas and, of course, after it had entered the nest box for there it was rewarded by finding a few grains scattered in the litter. In this manner a series could be completed in about 15 minutes after which the chick was taken from the experiment box and given more food and its freedom in the room. This procedure could be carried out until the chick's hunger was satisfied after which the tests went so slowly and with such uncertainty that it was found best to postpone the work until the following morning. As the bird became older this mode of experimentation could be carried on as long as three hours.

While I was preparing test sheets or taking notes at my desk between experiments, No. 21 would crowd up about my feet and beg to be taken up. If it were allowed to perch itself on my arm it would sit there as long as I was quiet, contentedly preening its feathers and occasionally giving a short "hovering twitter."

From these facts, I am led to conclude that the chick really "enjoyed" the experiments.

Table 7 shows the results of my first study of form with No. 21. The chick was trained to go to the triangle and to reject the circle or square. While none of the results here recorded are clear cut, there is strong evidence that the chick was discriminating between the two stimuli. This experiment was hurried lest the chick should not remain in good physical condition, but at its conclusion the bird was in excellent health so the work was repeated with much more thoroughness.

TABLE 7

FORM PERCEPTION

No. 21. Hatched: February 9, 1912. Sex: ♀

| Discrimination | Series | Date | Right | Wrong | Time |
|---|---|---|---|---|---|
| △ 28+—⊙ 7+ | 6 | March 13 | 7 | 3 | 10″ |
| " —⊙ 12+ | 7 | " 13 | 9 | 1 | 11 |
| " —⊙ 15+ | 8 | " 14 | 8 | 2 | 18 |
| " —⊙ 19+ | 9 | " 14 | 4 | 6 | 12 |
| " — " | 10 | " 14 | 6 | 4 | 8 |
| " — " | 11 | " 14 | 8 | 2 | 33 |
| " — " | 12 | " 14 | 8 | 2 | 12 |
| " — " | 13 | " 14 | 8 | 2 | 12 |
| " — " | 14 | " 14 | 8 | 2 | 12 |
| " —⊙ 23+ | 15 | " 14 | 8 | 2 | 13 |
| " — " | 16 | " 15 | 8 | 2 | 6 |
| " —⊙ 24+ | 17 | " 15 | 8 | 2 | 13 |
| " —⊙ 25+ | 18 | " 15 | 9 | 1 | 6 |
| " —⊙ 26+ | 19 | " 15 | 6 | 4 | 17 |
| " —⊙ 27+ | 20 | " 15 | 8 | 2 | 18 |
| " —⊙ 28+ | 21 | " 15 | 7 | 3 | 17 |
| " — " | 22 | " 16 | 9 | 1 | 8 |
| " —□28+ | 23 | " 16 | 9 | 1 | 40 |
| " —⊙ 63+ | 24 | " 18 | 6 | 4 | 56 |
| " — " | 25 | " 18 | 6 | 4 | 85 |

The last two series (24 and 25) of table 7 were introduced as control tests. The circle was larger than the triangle, hence it afforded an opportunity to see if the chick would react to form difference, after this training, rather than size difference. Apparently it was demanding too much of the chick, for No. 21 became discouraged at this point and the training had to be repeated.

In table 8 is presented the results of the re-training of No. 21. While the record, as shown in the table, is quite convincing

TABLE 8

FORM PERCEPTION: △ 28+—⊙ 28+

No. 21. Hatched: February 9, 1912. Sex: ♀

| Discrimination | Series | Date | Right | Wrong | Time |
|---|---|---|---|---|---|
| △ 28+—⊙ 9+ | 9 | March 20 | 10 | 0 | 6 |
| " —⊙ 12+ | 10 | " 20 | 10 | 0 | 14 |
| " —⊙ 15+ (inscription of triangle) | 11 | " 21 | 9 | 1 | 9 |
| " — " | 12 | " 21 | 10 | 0 | 9 |
| " — " | 13 | " 21 | 10 | 0 | 8 |
| " — " | 14 | " 22 | 10 | 0 | 6 |
| " —⊙ 19+ | 15 | " 22 | 5 | 5 | 15 |
| " — " | 16 | " 23 | 9 | 1 | 6 |
| " — " | 17 | " 23 | 10 | 0 | 6 |
| " —⊙ 23+ | 18 | " 23 | 9 | 1 | 7 |
| " — " | 19 | " 25 | 9 | 1 | 20 |
| ▽ 28+— (inverted)—⊙ 23+ | 20 | " 25 | 5 | 5 | 92 |
| △ 28+ (upright)—⊙ 23+ | 21 | " 25 | 8 | 2 | 20 |
| " — " | 22 | " 26 | 10 | 0 | 17 |
| " —⊙ 25+ | 23 | " 26 | 10 | 0 | 12 |
| " —⊙ 27+ | 24 | " 26 | 8 | 2 | 12 |
| " — " | 25 | " 26 | 9 | 1 | 6 |
| " — " | 5 | " 27 | 8 | 2 | 35 |
| " — " | 6 | " 27 | 6 | 4 | 8 |
| " —⊙ 28+ | 7 | " 27 | 8 | 2 | 9 |
| " — " | 8 | " 28 | 10 | 0 | 5 |
| " — " | 9 | " 28 | 10 | 0 | 9 |
| △ 11+ (inscribed)—⊙ 28+ | 10 | " 28 | 6 | 4 | 40 |
| △ 28+—⊙ 28+ | 11 | " 28 | 10 | 0 | 15 |
| " — " | 12 | " 29 | 9 | 1 | 5 |
| ▽ 28+ (inverted)—⊙ 28+ | 13 | " 29 | 2 | 5 | 83 |
| △ 28+ (upright)—⊙ 28+ | 14 | " 29 | 9 | 1 | 7 |
| " — " | 15[1] | " 30 | 7 | 0 | 6 |
| " — " | 16 | " 30 | 9 | 1 | 7 |
| " — " | 17 | " 30 | 10 | 0 | 24 |
| " — " | 18 | April 1 | 10 | 0 | 15 |

[1] In series 15 the triangle was inverted during tests 5–7; the result was 2 wrong choices with an average time of 39 seconds.

that the chick discriminated between the triangle and the circle, it is, nevertheless, equally convincing that the chick did not perceive the form difference. It had reacted properly to the △ 28+—⊙ 19+ and —⊙ 23+ when the apex of the triangle was at the top, but when the triangle was inverted (series 20, March 25) the animal did not choose the triangle more than half of the time. With the triangle again upright, the correct reactions returned. Proper responses were secured when the areas were equal, (series 8 and 9, March 28), but when the inscribed triangle was substituted for the standard, the chick was again confused. Series 13, (March 29), another case where the triangle was inverted, gave more decided negative results which were immediately preceded and followed by almost perfect reactions. As a further test of the effect of inverting the triangle, the inversion was made during a regular series, 15, (March 30). The result of the inversion during tests 5–7 was one right choice, out of 3 chances with an average time of 39 seconds. These three special tests were preceded and followed during the same series with *perfect* tests the time of which averaged *less than one-third* that of the special tests.

In connection with these results, I present in detail the behavior of No. 21 when it was given △ 28+—⊙ 63+ discrimina-

TEST SHEET

Title of investigation, Form: △ 28+—⊙ 63+
Experimented on, 21
Harvard Psychological Laboratory, March 18, 1912
Record Sheet, 2; Series, 24

| Test | Behavior | Record |
|---|---|---|
| 1 l | $/// - \overline{///} + \overleftarrow{///}\ \underset{\frown}{\circ} - \overline{\overline{///}} + ///\ ''$ | O–65 |
| 2 r | $/// + ///\ ''$ | O–7 |
| 3 l | $/// - \bar{/}\,\bar{/}\,\bar{/}\ \triangle^1 + ///\ ''$ | E–1–14 |
| 4 l | $/// - /// + /\wr\wr + ///\ ''$ | O–14 |
| 5 l | $/// - ///\ \triangle^1\ ^{\overline{'''''''''}} + ///\ ''$ | E–1–55 |
| 6 r | $/// - + ///^{\overline{''''''''''}} - ///\ \underset{\frown}{\circ} + // - \bar{/} + \overline{//}^{\overline{''''''}} - \triangle^2 + ''$ | E–2–171 |
| 7 r | $/// + // - // + // + ^{\overline{'''''''}} + // - ^{\overline{''''''''}} + ///\ ''$ | O–94 |
| 8 r | $// + //\wr\wr - //\ \overline{\overline{\wr\wr}}^{\overline{'''''''}} + //\ ''$ | O–69 |
| 9 l | $/// + ///\ ''$ | O–4 |
| 10 r | $/// - /\ \underset{\wedge}{\circ} + \overline{\overline{\wr\wr}} - / + /^{\overline{''''''}} - //\ \triangle^1 + //\ ''$ | E–1–70 |

6–4–563.

tion. These tests are reported in table 7 as series 24 and 25. The test sheets show how utterly confusing to the chick was this condition. The results of this test were verified in the series recorded in table 8 under date of March 28 where the record is the same and the behavior was very similar.

Finally this chick's response to the circle-triangle was tested. The reversion of the condition for discrimination was at first confusing to the chick, and much patience on the part of the experimenter was necessary. The plan now was to begin with

TEST SHEET

Title of investigation, Form: △ 28+—⊙ 63+
Experimented on, 21
Harvard Psychological Laboratory, March 18, 1912
Record Sheet, 2; Series, 25

| Test | Behavior | Record |
|---|---|---|
| 1 r | $///+//-///\underset{\frown}{\circ}\backslash\backslash-\overline{//}+\overline{//}-\overline{//}\underset{\frown}{\circ}+\overset{\equiv}{\bar{/}}\breve{\circ}-/\triangle^0+//$ 〃 | E–0–145 |
| 2 r | $///+\overline{//}\breve{\circ}\overline{''''''''}-///+\overset{\equiv}{\bar{/}}\breve{\circ}-//\underset{\frown}{\circ}+///$ 〃 | O–79 |
| 3 r | $///+-\underset{\frown}{\circ}+//\breve{\circ}\overline{''''''''}+///$ 〃 | O–45 |
| 4 r | $///\underset{\frown}{\circ}+///\breve{\circ}\overline{''''''''}-/+\overline{///}\overline{''''''''}+///$ 〃 | O–60 |
| 5 l | $///\underset{\frown}{\circ}-//+///-///\overline{'''''''''}+///-//\triangle^1+///$ 〃 | E–1–61 |
| 6 l | $//+///-\overset{\equiv}{\bar{/}}\breve{\circ}\overline{''''''''''}+///$ 〃 | O–33 |
| 7 l | $//+//-///\overline{''''''''''''''}-///\breve{\circ}-//+///$ 〃 | O–46 |
| 8 l | $///+///-\breve{\circ}\overline{'''''''''}+/-///\triangle^1+///$ 〃 | E–1–35 |
| 9 r | $///-///\underset{\frown}{\circ}\overline{''''''''}-//\overline{'''''''''''''''''}+///$ 〃 | O–99 |
| 10 l | $/-\overset{\equiv}{\bar{/}}\overline{''''''''}-\triangle^0\overline{''''''''''''''''''''}-\triangle^0\overline{''''''''''''}-\triangle^1+$ 〃 | E–1–243 |
| | | 6–4–84.6 |

⊙ 63+—△ 28+ and gradually to eliminate the size difference by substituting successively smaller circles. In this case the *right* stimulus area was the variable and the standard was the sign of "shock" and "no escape." From the tabulation of these results the early records are omitted since these tests were only made as a means of getting a discrimination between the later forms. The size of the circle was gradually decreased from ⊙ 63+ to ⊙ 38+ at which point the tabulation begins. About 400 preceding tests were necessary to bring the bird to the point in its training at which the records of the table commence.

Table 9 shows that the chick was able to acquire the circle-triangle habit. The plan of controlling the qualities other than form was carried out as heretofore explained. After No. 21 had acquired the ⊙ 28+—△ 28+ reaction, the order shown in the table was followed to determine whether or not the bird

TABLE 9

Form Perception: ⊙ 28+—△ 28+ and ⊙ 28+—□ 28+

No. 21. Hatched: February 9, 1912. Sex: ♀

| Discrimination | Series | Date | Right | Wrong | Time |
|---|---|---|---|---|---|
| ⊙ 38+—△ 28+ | 12 | April 20 | 10 | 0 | 4 |
| ⊙ 33+— “ | 13 | “ 20 | 6 | 4 | 7 |
| “ — “ | 14 | “ 20 | 5 | 5 | 7 |
| “ — “ | 15 | “ 20 | 7 | 3 | 5 |
| “ — “ | 16 | “ 20 | 8 | 2 | 8 |
| “ — “ | 17 | “ 20 | 6 | 4 | 6 |
| “ — “ | 18 | “ 20 | 10 | 0 | 8 |
| ⊙ 28+— “ | 19 | “ 20 | 10 | 0 | 5 |
| ⊙ 44+— “ | 20 | “ 20 | 10 | 0 | 5 |
| “ —▽ 28+ (△ inverted) | 21 | “ 20 | 9 | 1 | 5 |
| ⊙ 28+—△ 28+ (△ upright) | 22 | “ 21 | 5 | 5 | 6 |
| “ — “ | 23 | “ 21 | 6 | 4 | 4 |
| “ — “ | 24 | “ 21 | 6 | 4 | 7 |
| “ — “ | 25 | “ 21 | 3 | 7 | 6 |
| ⊙ 33+— “ | 1 | “ 21 | 10 | 0 | 4 |
| “ — “ | 2 | “ 21 | 10 | 0 | 4 |
| ⊙ 28+— “ | 3 | “ 21 | 10 | 0 | 5 |
| “ —▽ 28+ (△ inverted) | 4 | “ 21 | 6 | 4 | 5 |
| ⊙ 15+—△ 28+ (⊙ inscribed) | 5 | “ 21 | 4 | 6 | 11 |
| ⊙ 28+— “ | 6 | “ 22 | 8 | 2 | 10 |
| “ — “ | 7 | “ 22 | 8 | 2 | 7 |
| “ — “ | 8 | “ 22 | 10 | 0 | 6 |
| “ — “ | 9 | “ 23 | 8 | 2 | 5 |
| “ — “ | 10 | “ 23 | 8 | 2 | 5 |
| “ — “ | 11 | “ 23 | 9 | 1 | 4 |
| “ — “ | 12 | “ 23 | 9 | 1 | 7 |
| “ — “ | 13 | “ 24 | 9 | 1 | 5 |
| “ — “ | 14 | “ 24 | 9 | 1 | 4 |
| “ —□28+ | 16 | “ 24 | 5 | 5 | 5 |
| “ — “ | 17 | “ 24 | 5 | 5 | 3 |
| “ — “ | 18 | “ 25 | 3 | 7 | 4 |
| “ — “ | 19 | “ 25 | 6 | 4 | 4 |
| “ — “ | 20 | “ 25 | 5 | 5 | 6 |
| “ — “ | 21 | “ 25 | 8 | 2 | 6 |
| “ — “ | 22 | “ 25 | 5 | 5 | 4 |

actually depended upon form difference. If it had a perception of form such as has been found to exist for size, then no marked change in the results should have occurred when ⊙ 28+ was replaced by a circle that circumscribed or inscribed the standard triangle; and if the chick perceived three-sidedness or triangularity on the one hand and circularity on the other hand, there should have been no important modification of its reaction when the triangle was inverted.

The work on form thus indicated that the chick can discriminate between circles and triangles of equal area, and there are indications of a discrimination between circles and squares of equal area (witness series 21, April 25, table 9, and series 23, March 16, table 7), but with the application of control tests we have indications that *this discrimination is on some basis other than form.* The results from the inversion of the triangle indicate that the basis of choice depends upon the unequal stimulation of different parts of the retina. When the extended base of the triangle is so placed as to stimulate the region of the retina which was formerly stimulated by the apex of the triangle, the chick becomes confused. Under the conditions of the present experiment, therefore, I am forced to conclude that *the apparent reactions to forms are the result of keen perception of size differences.*

## V. RELATIVE VALUE OF SIZE, FORM, AND BRIGHTNESS

The preceding study of size and form can leave no doubt as to their relative importance in the chick's visual life. On the basis of trial and error it has been shown that the number of tests to produce any approach towards a perfect response to the circle-triangle is vastly greater than the necessary number in the case of the large-small discrimination. This study has also revealed the fact that even after perfect reactions to the circle-triangle were established, the form element played no part in the discrimination. The size element, under these conditions, is *the* important factor for the chick, and *form in the stricter sense* has been found to have no discriminative value.

A brief study was made to determine experimentally the relative importance of size, form, brightness, and general illumination. The subjects used were Nos. 15, 16, 17, 18, 20, and 21. They were trained to go to a triangle which had a greater area and was brighter than the simultaneously presented circle. The triangle also appeared in the compartment which was more highly illuminated than that in which the circle was presented. After the chick had learned to choose the triangle without any errors, all but one of these factors were eliminated. It was thus determined which factor had the greatest value for the chick.

This method, I clearly recognize, is not reliable. It was only adopted as a means of securing preliminary information on this particular problem. The most important defect which may be present is that it provides no certain way of ascertaining the threshold values for each visual factor. For example, a difference of 11 sq. cm. between the areas of the two stimuli may be high above the chick's threshold of difference, whereas the difference between a triangle and a circle may be scarcely above this liminal threshold. I had no way of equalizing the four factors for discrimination. Subsequent work such as that reported on size and form must determine these values for all of the "light" elements on the basis of right and wrong choices.

The amount of difference in brightness and general illumination was that which, under the mechanical conditions previously described, would result when the *right* source lamp was placed 125 cm. from its stimulus area and the *wrong* lamp was 240 cm. from its display surface. This caused a marked difference to the human eye both in brightness and general illumination. Table 10, however, shows that it was of little significance to the chick. According to the averages, size was the first factor; *right* choices depending upon it alone amounted to 86%. Brightness and general illumination combined stand next with nearly 70% of *right* choices, and form stands last with the *right* and *wrong* choices nearly equal. Considering these results in connection with those previuosly presented on size and form, it seems highly evident that *the relative values of light factors for the chick's vision is respectively size, brightness and general illumination, and form.*

## VI. GENERAL IDEA

The frequent recurrence of discussions relative to the general idea in connection with animal studies has had the effect of keeping before me, during the present study, the question whether or not the chick has a general idea of sizes and forms. Accordingly, after several subjects had been trained to make

## TABLE 10

### Relative Values of Visual Factors

| Condition of Discrimination | Series | Date | Subjects | | | | | | | | | | | | | | | | | | Average | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 15 | | | 16 | | | 17 | | | 18 | | | 20 | | | 21 | | | | | |
| | | | R | W | T | R | W | T | R | W | T | R | W | T | R | W | T | R | W | T | R | W | T |
| △ 28+ brighter and in lighter compartment than ⊙ 7+ . | 1 | Feb. 20 | 10 | 0 | 34 | 8 | 2 | 40 | 9 | 1 | 16 | 8 | 2 | 40 | 7 | 3 | 40 | 9 | 1 | 10 | $8\frac{1}{2}$ | $1\frac{1}{2}$ | 30 |
| | 2 | 22 | 10 | 0 | 8 | 8 | 2 | 10 | 9 | 1 | 10 | 10 | 0 | 5 | 7 | 3 | 33 | 9 | 1 | 18 | $8\frac{5}{6}$ | $1\frac{1}{6}$ | 14 |
| | 3 | 24 | 9 | 1 | 8 | 8 | 2 | 21 | 10 | 0 | 7 | 10 | 0 | 8 | 8 | 2 | 12 | 10 | 0 | 5 | 9 | 1 | $10\frac{1}{6}$ |
| | 4 | 26 | 10 | 0 | 3 | 6 | 4 | 35 | 10 | 0 | 6 | 9 | 1 | 4 | 9 | 1 | 10 | 10 | 0 | 3 | 9 | 1 | $10\frac{1}{6}$ |
| | 5 | 27 | 8 | 2 | 11 | 7 | 3 | 24 | 9 | 1 | 22 | 7 | 3 | 16 | 9 | 1 | 21 | 6 | 4 | 12 | $7\frac{2}{3}$ | $2\frac{1}{3}$ | $17\frac{2}{3}$ |
| | 6 | 28 | 9 | 1 | 7 | 9 | 1 | 7 | 10 | 0 | 6 | 10 | 0 | 4 | 10 | 0 | 7 | 10 | 0 | 3 | $9\frac{2}{3}$ | $\frac{1}{3}$ | $5\frac{2}{3}$ |
| | 7 | 29 | 9 | 1 | 14 | 9 | 1 | 4 | 10 | 0 | 5 | 9 | 1 | 6 | 10 | 0 | 8 | 10 | 0 | 2 | $9\frac{1}{2}$ | $\frac{1}{2}$ | $6\frac{1}{2}$ |
| | 8 | 29 | 10 | 0 | 3 | 9 | 1 | 9 | | | | 10 | 0 | 2 | | | | | | | $9\frac{2}{3}$ | $\frac{1}{3}$ | $4\frac{2}{3}$ |
| | 9 | Mar. 1 | 10 | 0 | 5 | 10 | 0 | 20 | | | | 10 | 0 | 7 | | | | | | | 10 | 0 | $10\frac{2}{3}$ |
| | 10 | 1 | | | | 10 | 0 | 12 | | | | | | | | | | | | | 10 | 0 | 12 |
| Form and size...... | 11 | 1–2 | 8 | 2 | 8 | 9 | 1 | 22 | 6 | 4 | 4 | 8 | 2 | 10 | 10 | 0 | 4 | 9 | 1 | 2 | $8\frac{1}{3}$ | $1\frac{2}{3}$ | $8\frac{2}{3}$ |
| Form............. | 12 | 2 | 3 | 3 | — | 3 | 3 | — | 3 | 3 | — | 2 | 4 | — | 4 | 2 | — | 4 | 2 | — | $3\frac{1}{6}$ | $2\frac{5}{6}$ | — |
| All factors combined | 13 | 4 | 10 | 0 | 6 | 9 | 1 | 45 | 10 | 0 | 4 | 7 | 3 | 36 | 10 | 0 | 4 | 10 | 0 | 3 | $9\frac{1}{3}$ | $\frac{2}{3}$ | $16\frac{1}{3}$ |
| Size.............. | 14 | 4 | 9 | 1 | 7 | 9 | 1 | 30 | 10 | 0 | 3 | 8 | 2 | 4 | 9 | 1 | 3 | 7 | 3 | 6 | $8\frac{2}{3}$ | $1\frac{1}{3}$ | $8\frac{5}{6}$ |
| Brightness and general illumination. | 15 | 5 | 5 | 5 | 9 | 6 | 4 | 26 | 9 | 1 | 5 | 7 | 3 | 3 | 7 | 3 | 7 | 7 | 3 | 5 | $6\frac{5}{6}$ | $3\frac{1}{6}$ | $9\frac{2}{3}$ |

perfect reactions to the condition ⊙ 28+—⊙ 12+, I tested, without further training, their reactions to two different circles the sizes of which bore the same relation to each other as that of the former pair. This test was made for two different pairs of circles to determine whether or not a chick trained to choose the larger of two stimuli will choose the larger of two other stimuli that are larger or smaller than, but have the same proportion in size as those with which it was originally trained.

The diameters of the circles used in ⊙ 28+—⊙ 12+ discrimination are respectively 6 cm. and 4 cm. The variable, therefore, is two-thirds of the standard. After the chick had reacted perfectly to the 6-4 circles, they were replaced with two circles having diameters respectively of 4 cm. and 3 cm., *i.e.*, having the same difference ratio. In the next place they were replaced with two 9-6 circles in which case the difference ratio again remained unchanged. All of the subjects, except No. 3, mentioned in the foregoing discussion, were tested in this manner.

The results of these tests for general ideas are briefly as follows: a chick which has been trained to choose a 6 cm. circle and *reject* a 4 cm. circle will *choose* the latter when presented with a 3 cm. circle. Likewise, it will choose a 9 cm. circle when presented with a 6 cm. circle. In the one case, what has formerly been the sign for a negative reaction is accepted as the sign for a positive reaction. In the other case, what has previously been the positive sign is rejected, when presented with a larger stimulus, as a "shock sign."

## VII. SUMMARY

Under the conditions of the present method, the chick's threshold of difference in size perception lies between one-fourth and one-sixth when the diameter of the standard circle is 6 cm.

Earlier experimenters on the chick's perception of forms have failed to eliminate all possible conditions for discrimination other than the factor of form. The chick can discriminate between circles and triangles and circles and squares which are equal in area, but, with the conditions as described in this paper, none of the subjects with which the present experiment has been conducted were able to discriminate between visual stimuli on the basis of form alone. Reactions ~~to~~ optical stimuli which have been interpreted by observers as indicating form discrimination are probably made on the basis of unequal stimulation of different parts of the retina. If local inequality of excitations on the retina be the basis of these reactions, then the apparent discrimination of form by the chick is, in reality, a keen perception of size differences.

In sharp contrasts with the reactions to form stimuli are the responses to sizes. A chick can acquire a perfect circle-triangle reaction, but control tests show that it has no general idea of circularity in contrast with triangularity. On the other hand, a "large-small" trained chick reacts positively to the larger of two stimuli even though this particular stimulus had been the "shock" stimulus in previous experiments.

The order of importance of factors in the chick's vision is size, brightness and general illumination, and form.

# NOTES ON THE DEVELOPMENT OF A YOUNG MONKEY

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Seven Plates

Since some interest attaches to the development of the young of any species of animal on account of its bearing upon the control of experimentation in behavior work, it seems worth while to present the diary given below of the growth of a young *Macacus rhesus* monkey. The diary affords some rather interesting points of comparison between the development of the human infant and the young monkey. While comparisons can not be closely drawn it may be said at the outset that the difference in the motor and sensory preparation of the two species of young at birth is enormous and that the more rapid course of development in the young monkey is still more remarkable. We were not at all prepared to find the absence of a prolonged period of infancy in the monkey. That this is the case is apparent from our notes.

The two male monkeys in the Johns Hopkins Laboratory were purchased at Chicago in 1904-1905. The older monkey, Jimmie, was probably at the time of purchase three years old, and the second, Billy, about one year of age. The female, Dolly, was purchased in Baltimore in 1907. She was probably three years old at purchase. Their ages now are (J) eleven, (B) eight, and (D) eight respectively. Until 1911 the monkeys lived together at various times in the ordinary large laboratory cages. A change was then made so as to give the animals greater freedom. A yard was fenced in which connected by a chute (12″ x 12″) with a steam heated room. The animals could spend their time at will either in the yard or in the room. Even in the coldest weather a large part of their time was spent in the open yard.

During the three or four years prior to this change in their living arrangements copulation between J. and D. took place frequently but there was never any evidence of conception resulting. We were accordingly not expecting the birth of the young monkey nor did the female show, even up to the time of parturition, any signs of pregnancy which could be noted by external cursory examination. The time of gestation is therefore not determined.

Since we desired to keep the young monkey in good health no attempt was made to separate it from its mother. For this reason the notes are rather superficial—such as could be obtained by watching the animal's activities in the open yard.

*July 11, 1912. First week.*

The young monkey, a male, was born between 9 and 10 A. M. First observation at 1 P. M. The mother (Dolly) was sitting on the shelf,[1] crouched on her haunches and bent over. She supported the baby between her thighs, one of her hands about his back, the other (left) about his shoulders with the fingers passing under his left arm. The baby sits breast to breast with the mother, his right hand on her left shoulder, his left grasping the hair of her right side. His hind feet grasp the hair just above her hips. He nurses from the left breast. This seems to be the typical position for both in resting and sleeping.

When moving about Dolly carries him suspended under her breast, with one hand, usually the right, grasping his neck and holding him against her. Her other hand is used in walking and feeding. The baby grasps the hair of her sides with all four paws, his legs straight and extended up along her sides as far as they will reach. His eyes are closed and his face pressed tightly against her breast. He looses hold with his hind feet. Dolly stops and presses tightly against his neck. He kicks about and finally regains his hold.

Dolly objects to the presence of observers, watches us, and finally starts to go inside through the chute. At the passage she hesitates as though to make sure that her own body and that of the baby will go in. She holds him very tightly on entering.

6.00 P. M. Found them seated on the shelf in the usual position. Dolly catches the baby by the fore-lock and stretches the skin of his forehead tightly back, gazing intently at his face. She then fingers his eyes, nose and mouth. She grasps his right ear and pulls his head over to one side, looking for fleas. The baby cried out, a high-pitched, metallic squeak like that of a rat. The mother clasps him tightly for a moment in both hands, then resumes her search for fleas. The baby grows restless, stops nursing, and moves his head about, his eyes open. He is not able to hold or turn his head steadily.

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[1] The shelf is six feet from the ground and is eight feet long by ten inches wide. Ascent is made by a long, narrow, inclined plane.

6.15 P. M. The baby sits on the ground, still clasped in the mother's arms. His thighs are drawn up until the knees are almost even with his spine.

6.30 P. M. Dolly carries him constantly and keeps her back turned towards us most of the time.

6.40 P. M. Found her seated on the edge of the water bucket, a large galvanized garbage pail, trying to drink. When she stoops over the baby is in danger of dipping in the water. She makes several unsuccessful attempts to drink, but finally gives up and goes to the shelf. She almost immediately settled down for the night. Both went to sleep in about the position described before.

We were not able to disturb the baby by shrill whistling or to get him to attend to movement. The times when he looked around were very short, only a few seconds, and his eyes did not seem to be directed toward any particular object.

*July 12.* 7.00 A. M. Both were found still in the sleeping position. Dolly spends 10 or 15 minutes looking for fleas, then climbs down from the shelf and comes to the gate. She leaves the baby to cling fast by himself, instead of supporting him with her hand as she did yesterday. He holds with all four paws, one around her left foreleg. When he looses hold, as he frequently does, she lifts him back into place but does not support him there.

The baby seemed restless when one whistled within a foot of his ear, moved his head about, and finally looked around indefinitely, but did not appear to localize the sound. He would not follow a moving object with his eyes.

Dolly offered herself to Jim, the large male in the yard and father of the baby, for copulation, resting the baby on the ground and crouching over him.

5.00 P. M. Found her lying stretched out in the position of a sleeping cat, with the baby resting on the ground against her breast.

*July 13.* 12.00 N. The baby is stronger and holds to Dolly without slipping. He holds up his head more steadily and gazes about for half a minute at a time. He is much troubled by a cold. We offered Dolly bread and milk and when she took it, Jim, wanting it all, attacked her savagely. She did not fight back as usual but screamed and fled to the shelf. She seems weak today, rests the baby on the ground instead of holding him upright, for much of the time, and leans, herself, against the incline to the shelf. As she sits ordinarily her body offers a perfect protection for the baby. Her thighs protect his sides and her body is bent forward to form a roof, so that only the top of his head is exposed. She usually turns her back to the observer, keeping the baby hidden and glancing back over her shoulder.

My moving hand caught the baby's attention today. He opened his eyes wider and turned toward it. Later he turned his head to follow movements and, when his head was confined by Dolly's arm, turned his eyes. He does not yet attend to sounds, but this is not surprising on account of the constant racket made by terns confined in an adjoining yard.

7.00 P. M. The young one is lying on his back, his hind feet grasping the hair of Dolly's sides. He moves his hands about in an aimless way, grasping at her face. His movements are weak and inaccurate. Dolly licked his face for a few seconds. This is the only sign of cleaning that has been observed.[2]

Frequently in her flea hunting she is too rough and the baby cries. His cry has changed to a shrill chattering, "Chirk-chirk-chirk."

7.30 P. M. The monkeys are preparing for the night. Jim stretched out on the shelf and when Dolly edged over to him he drove her down to the ground. He has been growling at her all day.

*July 14.* It rained all afternoon and Dolly would not leave the shelf. Both she and the baby remained almost motionless all afternoon.

*July 15.* The baby is much more active today and spends much of the time looking around. He rides with his head turned away from Dolly. He shows especial interest in Jim, staring at him when he is close and moving, but not following him when he moves out of the direct line of vision. He twice reached out towards Jim, with a quick out-thrusting of the arm, followed by a sweeping movement. Usually the movements of the arms are restless and not directed towards any object. The thumb and fingers of his foot seem to be more readily apposable than they are in the adults.

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[2] From later observations it appears that this is only a method of catching fleas. Dolly has never attempted to wash or clean the baby.

When sitting on the shelf Dolly does not hold him so closely as before, but allows him to lean back until he lies flat on his back.

Jim is becoming more abusive and does not allow Dolly to come near him.

*July 16.* The caretaker reports that as Dolly climbed down from one of the flying rings the baby scrambled around to her back and remained there until she reached the shelf, when he returned to his usual position. The baby is more active today than yesterday. He holds his head up steadily and gazes about; moves his arms about and fumbles at his mother's arms and shoulders.

2.00 P. M. Jim attacked Dolly savagely and we were forced to place Billy, another male monkey, and him, in the winter room adjoining Dolly's yard. When the separation of the monkeys was attempted all were badly frightened and Dolly tore about the cage, leaping to the sides and roof and finally dropping from the roof to the ground. The caretaker stood before the connecting chute after Jim and Billy had entered and Dolly rushed against him violently enough to bruise him severely. At some time, probably when Dolly leaped down from the roof, the baby received a cut above the left eye and a bruise on his right hand. Nevertheless he clung tightly to Dolly without her help during the whole commotion. He cried out only once, when she leaped from the roof.

As soon as the chute was closed Dolly became quiet, but went to the window and peered in several times. The baby held tightly to her, with his face close to her breast, for the remainder of the afternoon.

*July 17.* The baby is very quiet today and seldom turns his face away from Dolly. He sneezes frequently and always cries afterwards. When he cries Dolly gathers him to her closely.

I was not able to attract his attention by any noises, but when, rarely, he looked around he was attracted by my moving hand, and followed its movements with his eyes.

*July 19. Second week.*

In catching fleas Dolly frequently pinches the baby with her lips, making him squeal. When he cries she pauses in her flea catching and draws him close, then licks her lips and looks at the sky. In half a minute she is at it again, turning back the hair from his skin and going over him from his nose to the tip of his tail.

In nursing, the baby bites her nipples until he makes her shudder. When he does this she generally looks down at him, then stands up and walks about.

He is beginning to show an interest in objects other than his mother. As she walks along he holds fast by three feet, and swings the other free, reaching toward the ground. He looks around actively all the time when not feeding. When Dolly is still he moves about restlessly in her arms, releases his hold on her fur, and rises slightly on his hind feet.

*July 20.* Today the baby tried to escape from Dolly's arms, twisting about and kicking violently. These movements did not seem to be purposive but were rather an undirected, violent squirming. He bites at Dolly's arms and his own hands. When he bit her teat today she first tried pushing his head about with her hands and when this did not make him quit, she pinched him on the shoulder with her lips. This made him chatter, when she immediately gathered him close. When Dolly walked her moving hand caught his attention and he snatched at it, tripping her. She pressed him up firmly into position and went on. This was repeated several times.

When looking at me he sometimes purses his lips and thrusts out his tongue and sometimes reaches towards me. Most of his movements are of the larger limb muscles; the fingers are not moved separately. He does not imitate any of Dolly's movements.

*July 22.* He is beginning to give Dolly trouble to hold him. As soon as she sits down he struggles to escape, reaching over her arm to the ground with his hands, then kicking out his feet.

At other times he tries to creep under her arm, but does not attempt to push it aside with his hands. Once he succeeded in throwing himself forward over her arm and stood alone. She caught him by one leg and pulled him back, then put her other hand around his neck and drew him into place.

He gives a scratching reaction today for the first time. The hind foot alone is used, scraping clumsily at his back and head. The movements are slow and uncertain.

He has grasped at several objects but does not pick them up, and he reaches out toward his mother's hands when she moves them. He frequently puts his hands in his mouth, especially fater he has scraped them along the ground, or has grasped at some object.

Some of his movements indicate a lack of distance perception. Gazing intently at some object (carrot) he throws himself violently forward over Dolly's arm, at the same time reaching out with both hands, as though in an attempt to grasp it, although it is as much as three feet away.

While he was facing away from her Dolly became frightened. She leaped to her feet, grasping him around the throat, and started to run away. When he cried out she stopped, looked down at him, then grasped him by one hind leg, turned him over into position, and ran on.

He now turns directly towards the source of sounds and follows movements accurately with his head. He attends much longer than at first, looking at the observer as long as half a minute at a time. Unlike the adults, he meets the eye readily. He would not reach toward a moving hand or a stick thrust into the cage.

*July 23.* The caretaker reports that the baby was out of Dolly's arms and walking for the first time at 10.00 A. M. today. At 1.30 Dolly climbed up on the gate. The baby dropped down between her thighs and hung by one hand for a few moments. When she is walking he clings to her tightly but the moment she stops he tries to escape. I gave Dolly a bit of chocolate. While she was eating it, the baby began to creep away. She put out a hand to stop him, thought better of it, and walked away a couple of feet, looking back at him. He began to crawl after her but his hind legs were too weak and he fell over. As he approached Dolly moved farther away, and finally the baby gave up and, turning aside, began to chatter. Dolly immediately came to him and picked him up. Five minutes later he escaped again. Dolly moved away from him about four feet and stopped, waiting for him to follow. He advanced a few steps then squatted down and looked around. Dolly immediately ran to the window and looked through at Jim, making threats. Baby turned toward the wall and began to chatter. Dolly became excited, ran from one window to the other, growling and barking. The baby became very much frightened, chattering continuously, and Dolly finally ran to him, picked him up, turned him over while running, and climbed to the shelf.

*July 24.* It rained almost all day and Dolly remained in the sleeping box on the shelf. I could not coax her out. The baby kept close to her and did not try to escape.

*July 25. Third week.*

Today for the first time I saw the baby use his hand effectively. While watching me, he grasped Dolly's left nipple with his right hand and carried it to his mouth. The movement was quick and accurate, quite different from his usual vague clawings.

He walks better today, having gained some control of his hind legs. He even managed a shambling trot for a few steps until one of his feet was misplaced, thus upsetting him. He shows little fear when left alone but watches his mother closely and keeps near her. He was out of her arms for about 15 minutes during the three hours that I watched. Squatting in front of the wall, he suddenly throws his body forward and thrusts his hands against it, at the same time pursing his lips and drawing up the corners of his mouth. This is repeated frequently and seems to be the first definite attempt at play.

Baby followed Dolly for about 15 feet. When she stopped and sat down he climbed against her back and began to muzzle about as though seeking her teat. She reached around, caught him by the neck and pulled him into position.

*July 26.* Baby was not on the ground during the time that the observer was present. He spent all the time in nursing or sleeping. A day of great activity seems to be followed by one of depression or exhaustion.

*July 27.* Today the baby is very active again, never still a moment, even when feeding. While on the ground he grasped a piece of paper, pulling it back and forth from one hand to the other. He finally dropped it and put his hands in his mouth. He bites at everything within reach; probably cutting teeth. He walks well although his hind legs are still weak. He tries to climb to Dolly's shoulders but is not strong enough to lift himself.

He sits in front of Dolly, facing her, then rises on his hind feet and thrusts out his hands against her. This is repeated frequently. Once he fell over backwards. Dolly was excited, ran to him, snatched him up and fled to the shelf.

While he was on the ground she climbed up to the shelf, stopping three times and looking back at him, as though coaxing him to follow. He put his hands upon the incline, but did not attempt to climb up. After a short time he began to cry and Dolly came down to him immediately.

When he is on the ground one cannot make the slightest movement without bringing Dolly to him, even when she has seemed to be looking the other way.

He found the wire on the water bucket. Grasping it with both hands he attempted to climb up, placing his feet against the side of the bucket. He could not lift himself. While Dolly was looking in at the window he fell down and gave a faint cry of fright. Dolly turned, reached him in two leaps, picked him up, chattered at me, and fled to the shelf.

*August 1. Fourth week.*

No new activities have developed during the last three days. Feeding has caused Dolly to lose her fear of me. She allows the baby to come quite near me, and only threatens when I move.

When he is on the ground he watches my movements almost constantly, coming up as close to me as he can and standing up against the screen. His movements, reaching, grasping, scratching, etc., are not very accurate. In grasping the thumb is not apposed to the fingers, but the hand is used as a sort of scoop, as is that of a raccoon. While he was near the netting I thrust my finger through to him. He nosed about and bit the finger, exposing his toothless lower jaw. After sucking at the finger he drew back with a frown.

His face is not mobile but he has three easily recognized expressions; ordinarily his face is impassive, with an expression of great seriousness, even melancholia; when he is satisfied or interested he sucks his tongue, pursing up his lips and chewing; when angry or disappointed he frowns. There is no expression comparable to the human smile.

He is quite unafraid and is attracted only by the observer's movements. He is frightened by squeaking or tearing sounds,[3] but not by whistling or clapping. He runs about actively and bites at every new object.

*August 3.* Baby climbed some distance up the wire netting today. When he was 18 inches from the ground Dolly reached up and pulled him down into her arms. He seems to enjoy climbing up and down the edge of the window sill, a distance of about four inches.

I put a bit of bread and milk in his mouth. He sucked at it but did not attempt to swallow it, finally letting it fall from his mouth.

He has learned to jump from the window ledge to the ground. Previously he would put his hands to the ground before dropping off, but now he drops boldly.

He tastes the bread and milk that I have given Dolly, usually placing his hands upon it and bending down to suck at it. Twice, however, he gathered a large piece of bread up into his arms, sitting back upon his haunches. The hands are not used well for grasping. He does not try to swallow the bread, but merely sucks at it. His biting seems now to be limited to light colored objects, bread, paper, carrot, etc. When Dolly is feeding and he approaches her she crouches down until her face is level with his, stares at him for a moment, then slaps or bites him. This makes him cry and she immediately draws him into position.

*August 7.* He is very playful today. He stands up on his hind feet, runs forward a few steps with arms outstretched, and pounces upon a piece of paper or other object. He climbs about the edge and sides of the water bucket. He does not seem to mind when his feet or tail get in the water. He reaches out, grasps and bites his food. His interest in the food is quite independent of Dolly's activities. He does not imitate her in eating or in other movements. She has never offered him food, —indeed she usually snatches it away from him and boxes him besides.

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[3] Noises of this type, rustling, tearing and squeaking sounds, seem to be particularly terrifying to the young of animals differing widely in habit.

His scratching reaction is complete today. The hind foot is moved quickly and accurately. The hand is used for scratching for the first time. The movements are exactly those of the adults. The wrist is held stiff and bent slightly inward, the fingers crooked. Even the adult's far-away look is assumed during the process.

*August 8 and 9. Fifth week.*

Cold rain. The baby was reluctant to leave Dolly's arms and would not venture far from her. He climbed up on the netting and some cake crumbs were placed in his mouth. He sucked at them but did not swallow.

*August 10.* He has cut lower incisors; tried to test his taste sensations today. He took sugar and acid solutions with apparent relish, coming back for more, but he turned away when salt was given. He ate bread and milk with apparent liking. When the observer quit feeding him he climbed up on the screen and, looking at him intently, he began to shake the screen, or rather, to bounce back and forth against it, since his weight was not sufficient to move the wire. He struck at Dolly when she pulled him down from the screen and was severely punished for it. She does not allow him to make threatening movements towards her, and she frequently bites him when he frowns at her.

*August 12.* Today baby apposed the thumb and fingers in grasping (first time actually observed). He could not pick up a grain of corn in this way. He frequently jumps off the window ledge and sometimes jumps into the air when running on the ground. He pounces upon various objects in the cage, but rarely picks them up, usually bending down and applying his mouth to them. He frowns very darkly when Dolly punishes him. When he is frightened he turns directly to her. When a piece of paper was crackled he looked back and forth from her to the observer, and finally began to cry.[4]

*August 14.* Attempted to test his sense of smell today. When he was offered anything through the screen he reached for it with one hand, then bent forward and took it in his mouth. He sometimes seemed to smell at it, but that this is not the case was shown by his biting at a cloth wet with ammonia. Only after two attempts to bite the cloth did he show signs of displeasure at the odor. He drew back also from a cloth wet with chloroform, shaking his head from side to side and wrinkling his nose. He seemed indifferent to the odor of oil of cloves or acetic acid. Dolly now releases him on the shelf but does not leave him alone there. She watches him closely to see that he does not fall off.

*August 16. Sixth week.*

He is beginning to recognize food, apparently, for his biting is limited almost entirely to scraps of food scattered about the cage. He chews and swallows bread.

*August 18.* His interest in food is increased and he spends much of the time nibbling at scraps. His interest in our movements is decreasing, and we cannot coax him to the screen as readily as before.

He climbed up the screen and, holding with his hands, began to dance against it with his feet (the shaking reaction shown by Jim). He kept his eyes fixed upon us all the time and stopped occasionally to peer through the wire, as though expecting some response to his action.

The water bucket offers a good place for climbing, and he frequently scrambles over it, turning and twisting about, hanging upside down, and reaching accurately for the wires and edge of the bucket.

When Dolly slaps him he shuts his eyes tightly.

*August 19.* Dolly was sitting on the edge of the bucket and he was hanging to the screen opposite her. Letting go of the screen with his hands, he turned and sprang across the bucket, striking against her breast and catching at her shoulders. His hind feet dropped into the water, but Dolly caught him and drew him up into position.

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[4] This is an action that has been frequently noted in the adults. When Dolly becomes enraged at some act of the observer, she does not herself attack but turns to Jim, the large male, and induces him to take the offensive. The behavior of the baby resembled this action of hers very closely.

*August 20.* I pinched his toes when he had climbed up on the screen. He scrambled away and when I quit he gave a slight shaking reaction, dancing up and down against the screen.

*August 21.* Dolly left him alone on the shelf while she came down to eat. He began to cry as soon as she had left him, but made no attempt to get down. After a few moments Dolly climbed back to the shelf and carried him down.

His grasping is now almost wholly with the thumb apposed, and he is able to pick up small objects such as broken grains of corn.

*August 26. Seventh week.*

Baby is beginning to notice his own body. Up till now he has occasionally caught hold of his feet, but has never looked at them while holding them. Today he caught hold of his toes and looked at them carefully, spreading them apart with his fingers. He caught the skin of his breast, spreading it out, examining it for a long time. Other parts of his body were also explored. He picks at Dolly's body too, especially at her right nipple and at her chin.

When we took the camera into the cage he was quite unafraid and persisted in coming close after the camera was focused.

I dropped a bit of bread through the screen to him. He lost sight of it and commenced to scratch around as though looking for it. However, as he has never been attracted by food when it fell near him, it is possible that this activity may not have been related to the sight of the bread.

*August 27.* Baby is jumping today to a much greater extent than usual. He runs and springs up into the window ledge. He also leaps against the water bucket and springs up and catches its top (about 18″ in height). The movements involved here are not different from those in his earlier play activities, but the energy expended is now sufficient to lift him from the ground. From general observations I had gained the idea that he is somewhat left-handed. Today, however, he grasped first at various objects 17 times with the right hand and 13 times with the left. Later, more extensive observations show that he is practically ambidextrous.

*August 31. Eighth week.*

Monkeys were fed green corn on the cob and syrup soaked rolls. They are especially fond of the latter. The mother immediately took possession of the rolls, after husking the corn. She carried both to the shelf. She forced the young monkey out of her arms. He began to eat in a half-hearted way at the corn but tired of it and approached the mother and reached out for the rolls. This led to severe and continued chastisement. She first pulled him away, holding him on level with her eye, and looking fiercely at him all the while. Then cuffed him with the paw, and bit him upon the skin of the head and back. The young monkey was forced to keep out of her reach. He became very angry, chattered and hopped up and down in one place, which seems to be the simian infantile way of expressing anger. He left the mother for the whole length of the plank and concealed himself behind the sleeping box. When I made noises designed to frighten them she would go over to the young monkey and place him in position but would not allow him to nurse. She will not allow him to touch food which she is holding in her hands. The forcing away of the young monkey and her increasing unconcern about him lead us to believe that this is about the time that weaning begins under natural conditions and at this age (seven weeks) he might easily be removed from the mother.

*September 2.* The young monkey is in a very playful mood. Spent nearly an hour out of mother's arms. Practiced jumping and climbing most of the time. Co-ordination much more advanced. Began climbing up about two feet on the wire netting, then turning with back to wire and jumping two feet into yard. Did this several times. Began new set of play movements; climbed up 18″ to 20″ and then turned back to netting, held on with right hand and slowly put left up over shoulder and back until he caught the wire and remained in that position for several moments. He seemed to get a good bit of fun out of this for he did it several times. Would crumple up a piece of paper and spring up and back from it again and again. Tried to interest mother in the game. Struck at her with left fore foot and then sprang on paper and partially rolled over on it much as a kitten does. Picked up a piece of roll from yard with fore paw and put to mouth and bit off small piece, reached up with left hind foot and grasped it much as the adults do. Came to opening and bit off piece of banana, chewed it with effort and swallowed some of it. Caught clear view of mouth. Both upper and lower incisors are cut and evenly grown but no molars either in upper or lower jaw.

No sign of sex interest even in play. Seems never to be interested in sex organs. Yesterday mother went over him for nearly half an hour, carefully picking over sex organs. No evidence of tumescence or of movements indicative of sex impulses.

Was very venturesome in climbing today. Climbed up the sides of the fence for three feet—came down, then went to top of fence and climbed with body inverted along top of fence. Got frightened. Twice essayed to get back to sides of fence, hanging suspended with three feet while groping for sides of fence with other. Although he could easily make it he could not gather courage to release the three feet attached to the overhead netting. Finally cried and mother climbed up, grasped him by back of neck and easily pulled him into position. These release movements of digits do not seem well co-ordinated. Often in attempting to climb down from netting the toes and fingers fail to release promptly.

*September 5.* Noticed use of cheek pouches for first time. Was eating rolls, and apparently with relish began stuffing into pouch with all the vigor of an adult.

*September 7. Ninth week.*

Eating much larger quantities of food but still nursing as vigorously as ever from mother. Ate almost a quarter of a banana. Gave it in small quantities from my finger. Had good opportunity to investigate teeth. No appearance yet of molars. For the first time he used fingers almost exclusively for picking up food. Picking up small bits nearly everywhere. Hitherto his grasp has been insecure. Still there is a long latent period both in closing and in releasing. Shown when I gave grain. Picked up large handfuls, letting most of it slip to ground. Usually managed to get one sun-flower seed into his mouth, "gummed" it round and round but did not crack hull.

*September 9.* Uses pouch freely, using back of forefinger as do adults for forcing food into mouth. Mother left him more freely than ever before. Uses the humped up, slow "lope" of adult. Covers ground rapidly. Enormous strides within last two days in motor development. Sure of his leaps and does not over-innervate and lose control. Today for first time left mother and ran up inclined plane almost to top. Could not get over edge. Mother paid no attention to him but ran on up incline and sat on shelf. After three or four efforts youngster clambered over and sat on shelf. Mother left him to clamber down for food. Played on shelf for half an hour. Mother lay down, fore-feet out like sleeping cat. Baby played leap-frog over her back, running the whole length of the shelf. At times would stop, sit on haunches, throwing up one hind-foot and slapping it with fore-foot. These movements were all of the relaxed and infantile type. They seemed to be a part of the play. Indeed, in all of his play movements there seem to be as many of the non-adaptive type as of the adaptive. Those multitudinous functions which are to be of use in the adult seem to gain in accuracy only by being exercised in the act for which they were intended, i.e., are slowly learned as they are called for.

Within the past week all of the vocal sounds of the adult have been heard with the exception of the ones which are used in the exercise of the sexual function. They are in a high falsetto key. Many of the adult expressive (emotional) movements are present. On viewing Billy through fence (Sept. 5) he began bouncing on fence with hind legs holding on by fore legs. Rotated skin of forehead and scalp up and down as he gazed fixedly at Billy and exchanged similar sounds with him. This type of behavior is like that exhibited by two adult strange monkeys placed in adjoining cages.

Even during this past week when the young monkey has begun showing independence the rigorous vigilance of the mother is never relaxed. She springs to him upon the occasion of any alarming sound or strange or sudden movement of the experimenter. She is growing more resentful of any liberties with her food.

*September 10.* Up to today signs of sex activity or interest have been lacking. Today erection appeared. Mother had fed, and had carried baby to the shelf. He was restless and danced about trying to get down. She tried to nurse him three or four times but he always struggled to free himself. Finally she held on tightly to him and began to pick him around the sex organs. Erection appeared. The mother continued to pull at organ and to push back fore-skin. Baby became very quiet and began to nurse, pulling at the short rope attached to her collar with one hand and reaching back to play with his own sexual organs. I have seen the mother pick over his sexual organs often before but this never before produced an erection. Apparently the testicles have not yet descended. They are plainly apparent, being lodged about two inches from the end of the scrotum. Whether there is any actual descension or merely downward growth from this point is not easy to say.

*September 12.* Baby very active. Mother at first would not come down for food. Young monkey made several tentative efforts. Finally mother came down without him leaving him upon the shelf. He was frantic and cried and danced in rage. She paid not the slightest attention to him and even when she went back she did not take him up or allow him to nurse. He was very eager to eat of her milk soaked bread but dared not reach for it. He made several playful strikes, rearing up on hind legs and striking with fore feet. Several times when he attempted to nurse she pulled him away and put her head down on a level with his and frowned in his face. We have here another step in the process of separation between the two.

*September 12–18. Tenth week.*

Eyes, which were deep blue at first, have changed into brown, characteristic of species. No evidence yet of cutting of molars. Seems to be slow period of development.

*October 21, 22, 23. Fifteenth week.*

For several weeks development of new responses has been slow. The monkey has been in the best of health and growth is apparently normal.

On the above dates it was noted that the young monkey was able to run down and up the inclined plane very readily. Long leaps and bold springs were taken. The mother came down quite often for food without him and often ran back carrying food but leaving young one behind. On the 21st he attempted to carry up his own food, a large piece of bread, in his paws. Dropped it when he started to climb. Went back for it and carried it up in mouth. Slides down the inclined plane as the fireman his pole. If he drops food from shelf or if mother drops food when he is without he runs down and takes it up. Now has a favorite place for eating, a beam resting about half way between ground and the shelf. Mother is now fairly independent. She knocks him around much as she would a smaller adult. Young one still nurses. As a rule she still carries him down. The protective instinct is still strong. Any noise or threatening movement will make her grasp him as of old.

The canine teeth are now well out. The molars are beginning to appear. Eating is evidently somewhat painful. He can eat only the softest food still. Peanuts, grain, sunflower seed, etc., are hardly touched. Milk soaked bread, soft baker's bread, bananas and grapes are all eaten with relish. He attacks the sweet potato and the carrot but makes no headway. Within the last fortnight control of hands is greatly improved, picking up tiny bits of food from between cracks, and small bits of banana from the wires. On the 22nd he peered underneath side of cage and caught sight of a brass padlock lying at my feet. Reached arm underneath and tried to pull lock forward. Mother immediately came up and peered through crack, drove young one away and tried on her part to draw lock forward. This type of imitation is evidently common in these animals.

From this period up to December 16th there has been very little to record. Due to the onset of cold weather all of the monkeys were again placed together. This made conditions rather unnatural because of Jimmie's continued cruelty. After a few days he had to be removed. The mother carries the baby constantly while in the enclosure with the other monkeys. The young one in his turn seems in constant fear of his life, rarely even attempting to get away from his mother. There are two more steps in the development which we would like to obtain—the age at which the mother entirely weans the young and the age at which sexual maturity is reached. Since under the present living arrangements of the monkeys these two observations are hard to obtain, we have decided to present the work as it stands.

The most complete as well as the earliest published observations upon the young of this species are those of Cuvier. The original publication has not been available but Brehm quotes from it in full, and for purposes of comparison it has seemed best to repeat his quotation here.[5]

> "Immediately after birth the young Bunder (*M. rhesus*) clasped himself to his mother's breast, holding to her hair with all four hands and seizing her nipple in his mouth. For fourteen days he did not leave his mother's breast. He remained, always in the same position, always ready to suckle; sleeping when the adult sits down, yet clinging fast to her even in sleep. He released one nipple only when he wished to grasp the other, and so the first days of his life passed without his having made a single movement except those of the lips, to suck, and of the eyes, to look about. Like all apes he was born with open eyes, and it seems that from the first moment he was able to distinguish his surroundings, for he followed every movement about him with his eyes.
>
> It is impossible to describe the care which the mother took for everything which concerned the feeding and the safety of her newborn. She appeared always intelligent, and so cautious as to compel admiration. The slightest noise, the least movement aroused her to watchfulness and to anxiety for her young one, not for herself, for she was accustomed to men, and had become quite tame. All her movements were performed with the greatest dexterity, yet never so that the suckling could have come to any harm. The weight of her young one seemed in no way to hinder her movements, and no difference in her dexterity or activity was noticeable. But indeed it was apparent that she took great care not to strike her baby against anything. After about fourteen days he began to leave his mother and showed, even in his first steps, a dexterity and strength, the more astonishing since neither practice nor experience could account for it. The young Bunder, from quite the beginning of his active life, climbed the upright wire grating of his cage and scrambled up and down at will; he made also a few steps on the straw, sprang voluntarily from the height of his cage, alighting upon all four hands, then against the grating, up which he climbed with the ease and rapidity which had been noted in the adult. The mother followed every movement of her child with the greatest anxiety and seemed always ready to ward off any harm from her loved one. Later she sought, from time to time, to relieve herself of the burden, but remained always watchful, and at the slightest sign of danger snatched him up immediately. The slightest touch of her hand was also a signal to her ready pupil to return, and he would instantly take his accustomed position on his mother's breast. The leaping and play of the little animal became more perfect as his strength increased. I have often observed his merry gymnastics with the greatest delight and can attest that I have never seen him make a false movement, or fail to take measure of and reach the point for which he aimed. The little ape gave me certain evidence that he could estimate distance and control the requisite degree of strength for each of his leaps. From the first moment he knew his natural movements and how to accomplish by them what another animal, even though possessing the intelligence of a man, could have done only after countless trials and long continued practice. Here, indeed, one may ask: What can we say in explanation of the actions of animals?
>
> After about six weeks a stronger nourishment than milk was necessary to the little ape, and here appeared a new phenomenon. Both animals showed a different aspect of their mental processes. The mother whom we saw before occupied with the most loving care for her offspring, who carried him constantly hanging to her body and breast, and of whom one would believe that, driven by maternal love,

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[5] Brehm, A. E. Thierleben, 1887.

she was ready to give him the last bite from her own mouth, the same mother did not allow him to touch the slightest bit of food offered to him. As soon as the keeper had given them bread and fruit she took possession of it, thrust the young one away when he wished to eat, and hastily filled her cheek pouches and hands, so that there was nothing left for him. It would be a mistake to believe that a nobler motive than gluttony impelled her to this act. She could not have wished to force the young one to suck, for she had no more milk; no more could it have been care lest the food should be injurious to him, for he ate it greedily and thrived on it. Hunger now soon made him very bold, venturesome, and nimble. He could no longer be driven back by the mother's blows, and in spite of everything that she could do to keep her child at a distance and keep all for herself, the young one was always sly and quick enough to snatch one or another bit of food and to bolt it behind her back and as far from her as possible. This foresight was by no means unnecessary, for several times the mother ran to the furthest corner of the room in order to snatch back the food from her child. In order to ward off the results which must follow this unmotherly behavior we provided more supplies than the mother could eat or conceal in her mouth and in this way the baby was provided for. Thereafter he lived in good health and was fostered by his mother so long as he did not interfere with her food. He distinguished rather well people who fed or petted him. He was always goodnatured and, of the ape characters, showed only playfulness and agility."

That the rapid development of the Macacus monkey, so different from that of the human infant, is not persistent in the higher apes is shown in the following quotation from Wallace in which he compares a hare-lipped monkey (*M. cynomolgus*) with a young Mias or orang-outang which he had captured.[6]

"It was curious to observe the different actions of these two animals, which could not have differed much in age. The Mias, like a very young baby, lying on its back quite helpless, rolling lazily from side to side, stretching out all four hands into the air, wishing to grasp something, but hardly able to guide its fingers to any definite object; and when dissatisfied, opening wide its almost toothless mouth, and expressing its wants by a most infantine scream. The little monkey, on the other hand, in almost constant motion; running and jumping about whereever it pleased, examining objects around it, seizing hold of the smallest objects with the greatest precision, balancing itself on the edge of a box or running up a post, and helping itself to anything eatable that came in its way. There could hardly be a greater contrast, and the baby Mias looked more babylike by the comparison."

Finally, the following brief account by Ram Bramha Sányál is included as a description of these animals in their natural habitat.[7]

"The young monkey after birth attaches itself to its mother, and will not leave her for nearly a month, the mother nursing the young all the time with the utmost solicitude; after this time it will make little excursions on its own account, but is careful not to stray far, and at the slightest sound or movement it seeks refuge with her. The mother is unremitting in her vigilance over her offspring and in its personal wants and appearance. Compared with an orang-outang of the same age, a monkey is more helpful and intelligent, and in fact all its instincts are strongly developed at a comparatively early age. In about a month the young one begins to pick up grain and other food, and then the struggle for life soon begins, and the mother and the young one commence to fight over their food, although their natural instincts bind them to each other at other times."

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[6] Wallace, A. R. The Malay Archipelago, 1872.

[7] Ram Bramha Sanyal. A Handbook of the Management of Animals in Captivity in Lower Bengal, 1892.

## SUMMARY OF DEVELOPMENT

### *Physical*

At birth the little monkey was far advanced in physical development. His body, although less than 20 cm. in length, differed from the proportions of the adults to a much less extent than does that of most young animals. His head was disproportionately large, but not so much so as that of the human infant; his hind-quarters were considerably smaller proportionately than are those of the adult monkey. The body was covered with hair, distributed as in the adult with the exception of a peculiar bare line following the sagittal suture of the skull, where in the adult there is a heavy growth of hair. (This is shown distinctly in Plate II.)

The eyes were open at birth. They were at first light blue and did not reach the dark brown color of the adult until the ninth week.

As far as the crude methods employed could determine, the sensory development of the monkey seems to be complete at birth or shortly afterward; reactions to light appeared on the second day; painful and tactile stimuli brought responses on the first. The time of the beginning of the auditory function is not known with certainty but there is some evidence that sounds were heard on the second day. It was impossible to stimulate the other sense organs in order to determine their condition until much later, at which time they were completely functional.

The early, post-natal development was largely that of the motor apparatus, the range of activities keeping step with growth and increase in muscular strength. The rapidity of growth has been less than might have been expected to accompany the rapid increase in motor agility of the little monkey; the most marked increase in size being in the hind limbs. At the age of four months the baby has gained the proportions of the younger adults although his body length is less than one-half that of the adult.

The first teeth, the incisors, were cut during the fifth week; the molars did not appear until the 15th. Teething seemed to be somewhat difficult. The first manifestations of sexual activity were noted during the ninth week.

### *Sensory-Motor*

*First week.* On the first day the little monkey was very still, moving only when forced to do so by the movements of the adult. However, certain reflexes seemed to be well established even on this day. Those observed were sucking, grasping, muzzling, crying, sneezing, winking (not in response to visual stimuli), inco-ordinated movements of the legs when the stimulus for grasping was removed, and an increased muscular tension of the legs in response to the mother's movements.

During the second day there appeared to be a slight unadaptive response to sound. In the human infant this varies in time of appearance from the second to the tenth day. By the third day his strength had increased so that his grasp upon his mother's hair had become secure. The head and eyes were at this age first turned to follow a moving object. Two days later appeared the reflex grasping at an object seen.

*Second week.* By the end of the first week his muscular activity was greatly increased, although most of his movements were still of the non-adaptive type. Complex co-ordinated movements of the limbs, as in jumping, appeared, and voluntary reaching toward moving objects became more frequent. The scratching reflex was established. On the 11th day he reached out and grasped small objects. By this time his responses to sound indicated some degree of localization. On the 12th day he first attempted to walk. The movements were very badly executed and showed a decided lack of co-ordination.

*Third week.* The third week, the first week of walking, was marked by a tremendous increase in his muscular control. The movements of the larger muscles of the limbs became fairly well adjusted to the demands made upon them, and many infantile movements were gradually made adaptive. The first definite play activities appeared, with contractions of the facial muscles in pursing the lips.

*Fourth week.* Play rapidly changed from simple pushing and grasping to the more complicated stalking and capturing of objects in the cage. This was closely connected with his increased interest in scraps of solid food, as he first attempted to eat at this time. The scratching reflex was perfected. The very complex behavior of the adult appeared suddenly complete. There is some evidence to show that he recognized food by sight within a few days after he first tasted it.

*Fifth week.* Apposition of the thumb and fingers was first observed, muscular co-ordination spreading peripherally. Crude experiments on his sensations of smell and taste indicated at least a discrimination of stimuli as indifferent and unpleasant. He attempted to draw the mother into his play.

*Sixth week.* The adult expression of anger or impatience, shaking his support violently, appeared suddenly. The thumb was used much more in grasping.

*Seventh week.* The first definite signs of interest in his own body were observed.

*Eighth week.* The use of the cheek pouches was acquired during this week.

*Ninth week.* Different vocal sounds were first distinguished. The method by which they were learned is not known, but from their sudden appearance they seem to have been instinctive rather than imitative. The first sexual activity was noted during this week.

By the 10th week the young monkey had become mature in all but the sexual activities. He was lacking chiefly in muscular control.

*Fifteenth week.* From the 10th to the 15th week the progress made was almost entirely motor. Play activities were still very marked and unadaptive movements persisted.

## BEHAVIOR OF THE ADULTS

The maternal instinct in these animals seems to be limited to carrying and protecting the young one, permitting him to nurse and keeping him clean of parasites. Within these limits Dolly's care and watchfulness are unceasing, but beyond them she treats the baby much as she does the adults in the cage.

Her method of carrying and holding the baby is such as to afford him the greatest possible protection from enemies and from the weather. (Plates I and II.) Her patience in searching over his body for parasites is unlimited; greatly to the discomfort of the little one, to whose vigorous protests she pays no attention. No attempt at washing the baby, such as that described by Duvaucel [8] for the Gibbon, was ever observed. The rhesus monkeys are, in fact, quite careless of personal cleanliness.

The care of the baby brought about an interesting change in Dolly's relations to the other adult monkeys and to human observers. Where before she had been the most aggressive of the three, fighting for her food and keeping the others in fear of her, she now protected the baby by flight, showing a timidity quite at variance with her former disposition. The large male, Jim, was quick to notice this and soon became so savage in his attitude toward Dolly that it was necessary to put him in a separate cage.

The refusal of the mother to share her food with the young monkey has been noted with surprise by all observers of this species. Such a relation between parent and offspring is certainly rare among mammals and the extremes to which Dolly goes are without parallel. She has been observed to take food forcibly out of the baby's mouth and eat it herself, even when her own cheek pouches were distended to their full capacity. The significance of such an action is by no means clear. As Cuvier noted it is certainly not a means of protecting the young monkey from harmful food.

## PLAY

We were particularly interested in the play activities of the young monkey from their bearing upon methods of experimentation with adults. On the whole, his play is very simple, consisting only of random infantile movements, climbing, and stalking. The first type appeared on the third day when he clawed at Dolly's face and arms.

The first complex play movement appeared in the third week. Beginning as a simple thrusting out of his hands against his mother it developed rapidly into the more complex stalking of various objects in the cage. At this time also he began to take delight in climbing about the cage, twisting and turning in all directions and making little leaps to the ground. He sometimes appeared to wish to draw his mother into the play, stopping in the midst of his rapid climbing and striking out at her. For this, however, he was usually punished severely and so he never dared to persist in it. Often when Dolly lay down he would scramble back and forth across her body, but this is about the only familiarity she permitted him.

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[8] **Duvaucel: cited by Huxley. Man's Place in Nature, 1909, p. 43.**

The stalking play was at first directed toward all conspicuous objects in the cage, but as the baby learned to eat solid food his attention became more and more directed toward this, and his play activities to center around it. In all his play there appeared many of the relaxed idiot type of movements, as well as purposive ones. Plate V shows this sudden undirected expenditure of muscular energy, which was at first induced by the sight of food or of any other interesting object.

"Self imitation," so marked during certain stages of development of the human infant, was almost entirely lacking. The few actions which might be so interpreted were those of climbing and leaping, in which certain movements were performed repeatedly, with evident enjoyment of the activity itself. It is just here that self imitation would be most valuable, since the activities requiring the most accurate judgment of organic stimuli are involved. In most of his play, however, his interest seemed to be centered in external objects rather than in the movements themselves.

## LEARNING

Many of the little monkey's activities appeared suddenly, apparently without any preliminary practice, but others, particularly those requiring an adaptive response, were acquired only after many unsuccessful trials. New stimuli at first called forth an explosive reaction such as that shown in Plate V. Movements of all parts of the body were initiated, the reaction being wholly non-adaptive. Those random movements which resulted in manipulation of the stimulating object were repeated and the others gradually eliminated.

It is here that play seems to be of the greatest use, providing, as it does, a variety of undirected activities which are gradually moulded to meet the requirements of the environment.

# DESCRIPTION OF PLATES

The photographs from which the plates were made were all taken during the fourth week.

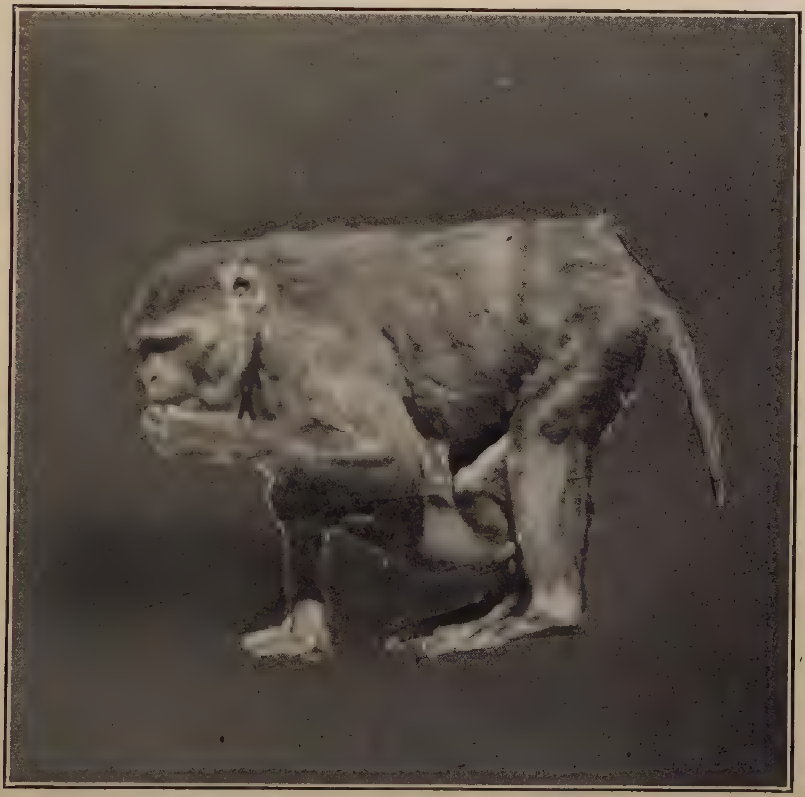

Plate I. The carrying position. The attitude of the monkeys in this photograph is not quite typical of the carrying position. Dolly has stopped and the baby is preparing to drop to the ground. He is consequently somewhat farther from Dolly's body than is usual.

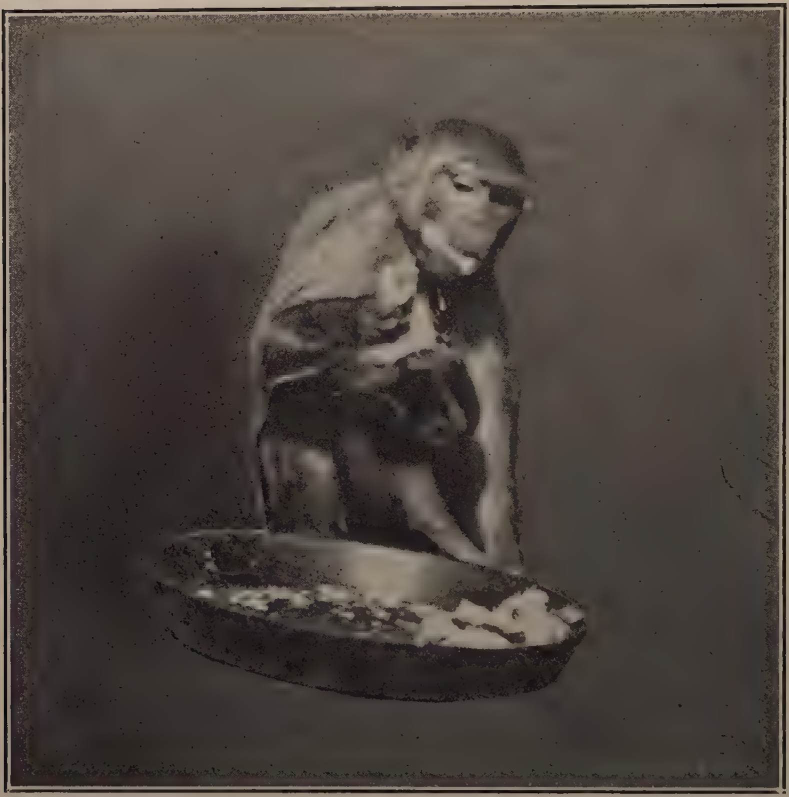

PLATE II. The nursing and sleeping position. Again this position is not typical as the baby is turned partly away from Dolly. One of his few imitative movements is shown, the reaching out after his mother's moving hands.

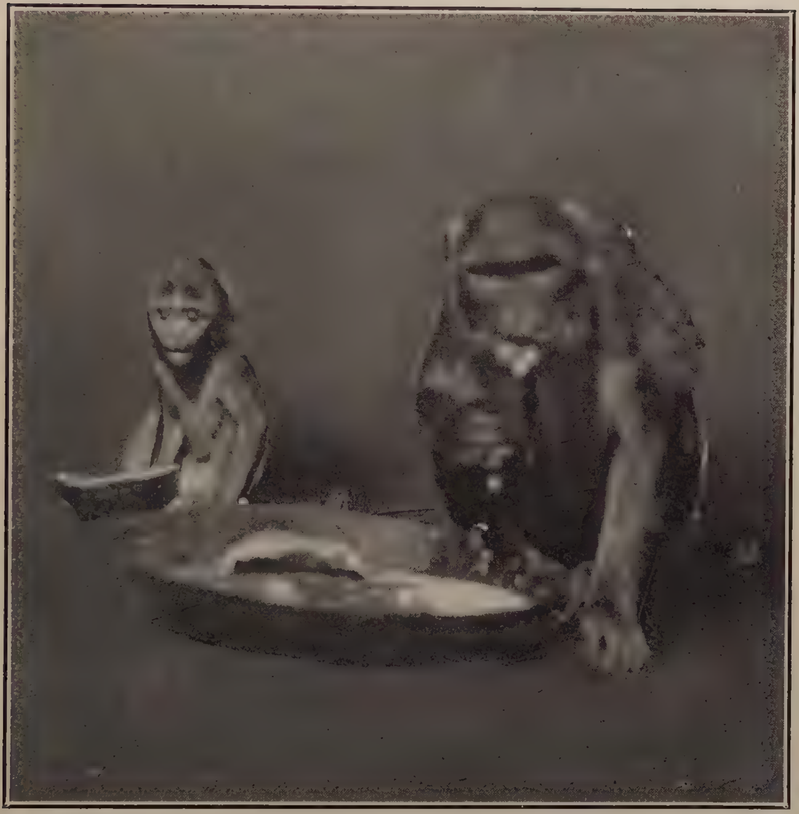

Plate III. His expression of fear is easily recognizable. Immediately after this exposure was made he turned, chattering, to Dolly and was carried up to the shelf.

PLATE IV. The instinct to keep the baby free from parasites is very strong. Dolly forgets her dinner when a good opportunity to examine his back is offered.

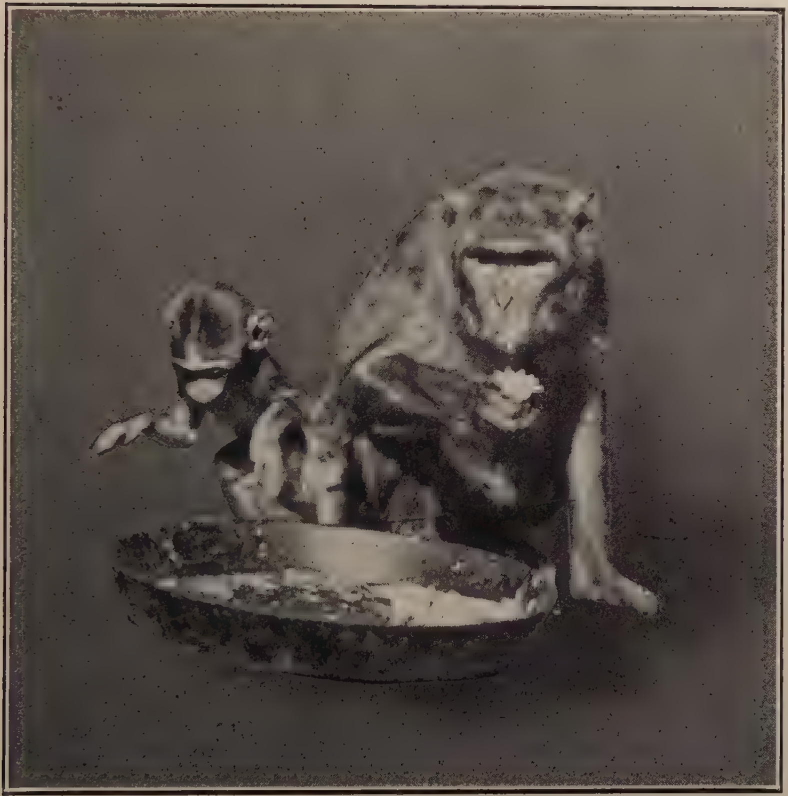

PLATE V. The non-adaptive infantile movements, so frequent at this time, are illustrated here. Later such excessive movements were brought under control and made adaptive in play.

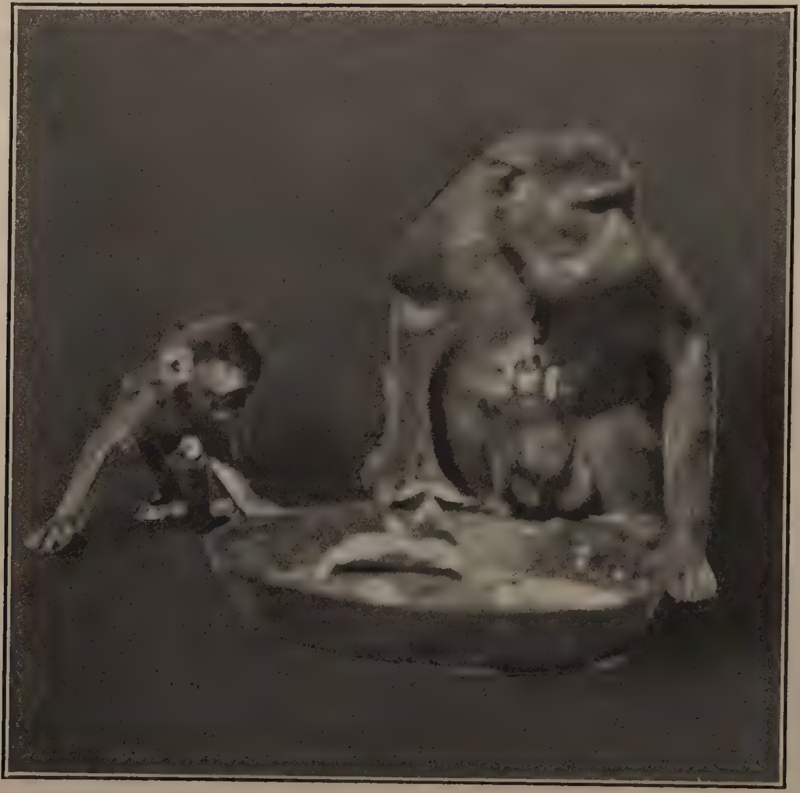

PLATE VI. The exposure was made after such a leap as that shown in Plate V. The movement seemed to have been excited by the food but his leap did not take him any nearer to it.

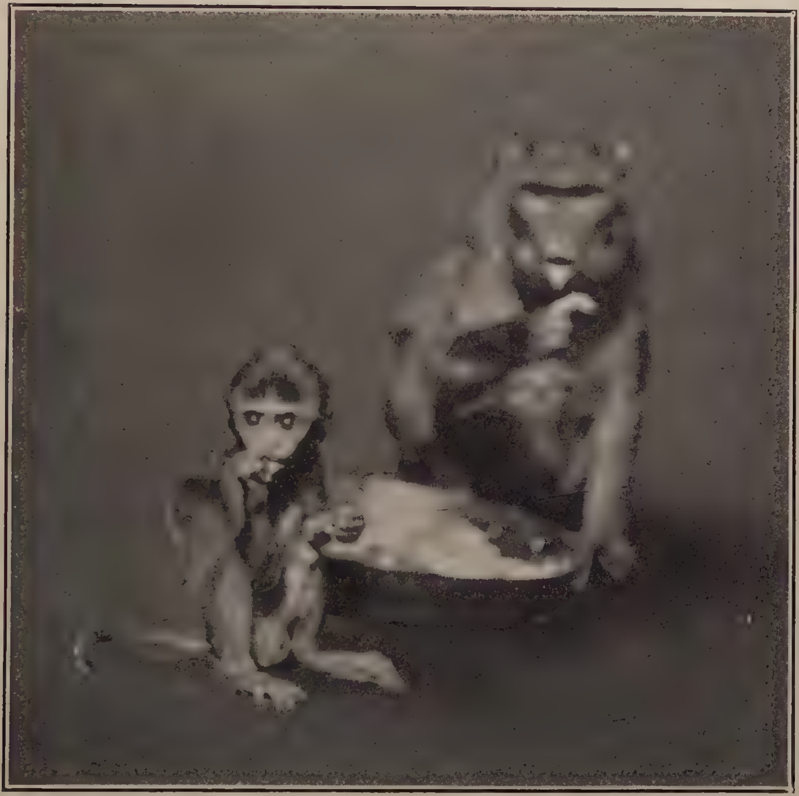

Plate VII. The early lack of co-ordination in grasping is shown. Compare the position of his hands with that of the mother in Plates I and II. (The curious hump on the baby's back in this photograph is due to an error made in blotting out the background, which was not discovered until too late for correction.)

Fewer data are at hand with respect to the method by which the more complicated reactions were acquired, and indeed so little is known with certainty of the conditions of discrimination and learning in the adult that a discussion of the questions involved here does not seem advisable. There is, however, no evidence to show that the infant monkey ever gained a new activity by imitation. Walking, climbing, leaping, eating, and even the different vocal sounds appeared as instinctive acts which were merely perfected by practice. Dolly's movements sometimes served to draw the baby's attention to some object, but his own reactions to it never seemed to imitate hers. At times also, his responses appeared to be determined by those of the adults, as when Dolly's threatening attitude after some acts of the observer induced fright in him although he had not shown fear at the act itself. His response in such cases was, however, quite different from that of the adult and in no sense imitative.

In conclusion we may say that this paper is primarily a record of the facts of behavior observed in the development of the young monkey. So little is known with certainty of the more complex activities of the adults that any explanation of the actions of the infant monkey in terms of adult behavior is extremely difficult. In view of this fact it has seemed best to make little attempt to interpret the data at hand until the psychology of the adults is more thoroughly understood.

We wish to express our indebtedness to Mr. Donald Mackenzie, to whose patience in the face of the most unfavorable conditions the excellence of the included photographs is due.

# OBSERVATIONS ON THE PREFERENTIAL USE OF THE RIGHT AND LEFT HANDS BY MONKEYS

SHEPHERD IVORY FRANZ

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In the course of a series of observations on the formation of simple habits by monkeys careful records were kept of the number of times each hand was used by an animal in taking the food which was presented. These observations are the data used in the preparation of the present communication. Six years previously I had observed that among a dozen monkeys certain ones tended to hold to the wire netting of the cage with one hand and to grasp with the other the food which was presented to them outside the cage. It appeared that there were marked individual differences, one animal apparently almost always using the right hand and arm for holding to the wire front of the cage and the left hand for taking the food, while another animal would reverse the hands in these two acts. These early observations were not systematically collected, but observations were made to determine whether or not it would be difficult to change the actions so that the animal which habitually used the right arm and hand to steady itself on the wire of the cage would learn to use that hand for grasping. It was found that after a few tests, twenty to thirty, in which the righthanded monkey was refused food when this hand grasped for it, and was given food in the left hand, this animal learned to hold with the right hand to the wire and to grasp for the food with the left. The ease with which the apparent habitual reaction was replaced by one of a different tendency led me to the belief that the apparent proneness to the exclusive, or almost exclusive, use of either hand might be due to any one of a number of extraneous factors, such as the position of the experimenter, his use of the right hand in delivering the food, etc. Further experiments to determine the truth or falsity of this belief were not made. Subsequently, the data presented in this paper were collected.

The monkeys used in this work were being trained previous to certain operative procedures on the occipital lobes.[1] They had been used in a previous investigation,[2] in which they had been fed from the front, sides, and bottom of the cage, and in which no attempt was made to have them use a special hand. During this latter investigation no observations were made of a preferential use of the hands. At the time the use of the hands was observed and the observations recorded, the animals were kept in cages 114 cm. high, 90 cm. wide, and 58 cm. deep. The front and right hand ends of the cages were covered with chicken wire, of one and one-half inch mesh. The top, bottom, the back and the left side were boarded. Within the cage there was a shelf 30 cm. wide jutting from the back of the cage at a height of about 45 cm. and extending the width of the cage. The animals were not handled and the environment, with the exception of the presence of the experimenter, was fairly constant during the progress of the experiments. Food and water, other than that used in the experiments were pushed through or under the wire front of the cage and the animal took of them when and as much as he wished. At the time of making the observations the animals were partly fed in the morning and the observations and tests made in the afternoon, or vice versa.

In performing the tests, the animal was in the cage, usually sitting upon the shelf. A glass plate, 12.5 by 18 cm., was arranged to hang horizontally on the wire netting of the cage, and was movable so that it could be placed upon any part of the front or right hand sides, i.e., those covered with the chicken wire. The food was placed upon the glass plate, this was arranged on the wire netting, and the experimenter moved away about a meter's distance. The animal, which usually during the preliminary arrangements sat at the farthest end of the cage, moved forwards and took the food. During the tests two pieces of food were presented, one of which was sweet, the other bitter. The arrangement of the relative positions of the two pieces of food was constantly changed so that half of the times the bitter bread was on the animal's right and half of the times on the left. At times the two pieces were only about 3 cm. apart, and at other times they were as much as 10 cm. apart. At all times they were sufficiently separated so that both pieces were to be obtained only with difficulty in one operation.

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[1] For details see Franz. The Occipital Lobes. *Psychol. Review Monog.* No. 56, 1911.

[2] Shepherd. Some Mental Processes of the Rhesus Monkey. *Psychol. Review. Monog.* No. 52, 1910.

Observations of the number of times each hand was used were made with six animals. Three of the monkeys were observed from the beginning until the end of the experimental series, and the other three were observed after they had formed the habit of taking one piece (the sweet) and disregarding the other (the bitter). Observations of two of the animals were continued after the extirpation of parts of the occipital lobes. The general results of the observations are given in tables I and II.

TABLE I

Total Number of Times Each Monkey Used Right and Left Hands During Period of Observation, Previous to Operation

| Monkey | Right hand | Left hand | Totals |
|---|---|---|---|
| 1 | 208 | 202 | 410 |
| 2 | 21 | 33 | 54 |
| 3 | 89 | 193 | 282 |
| 6 | 3 | 17 | 20 |
| 7 | 28 | 28 | 56 |
| 8 | 70 | 265 | 335 |
| Totals | 419 | 738 | 1157 |

TABLE II

Total Number of Times Each of Two Monkeys Used Right and Left Hands During Period of Observation Following Operation

| Monkey | Right hand | Left hand | Totals |
|---|---|---|---|
| 1 | 108 | 21 | 129 |
| 8 | 30 | 0 | 30 |
| Totals | 138 | 21 | 159 |

Monkeys 1, 3 and 8 were the animals which were observed throughout the period of training, and monkeys 2, 6 and 7 were observed only after the habit of taking the sweet food was established. The results from the first set of animals are the more interesting on account of the greater number of observations, although the results from the second set show the same general tendency. Table I indicates that monkeys 1 and 7 were ambidextrous; monkeys 3, 6 and 8 showed a decided preference for the left hand, and monkey 2 is in a doubtful class since a slight change in the totals might throw him into either of the above classes. Table II shows that monkey 1 after the operation showed a decided preference for the right hand, and that in the few observations with monkey 8 a similar tendency was present. It is possible that the effects of the operation, although on the occipital lobe, may have had an influence on the animal's use of the hands, and for purposes of a general comparison these results may properly be omitted. These animals did, in fact, show inaccuracies in movement following the operation, but I was not able to determine any difference between the two sides of the body.[8]

In 114 of the tests with monkey 1, the animal took both pieces of bread, and in 182 tests only the sweet bread. When only the sweet bread was taken, the right hand was used 70 times, the left 112; when both pieces of bread were taken the right hand was used 52 times for both pieces (104 times), the left hand 28 times for both pieces (56 times), and in 34 tests both hands were used, one piece being taken in each hand. In all tests in which both pieces of bread were taken we may count that one piece was to the right and the other to the left of the animal; in the tests in which only one piece was taken the food taken was 93 times on the right and 89 times on the left. No account was taken of the positions of the pieces of food which were taken first when the two pieces were picked up, so that any correlation between the location of the food pieces is impossible for the total series. Only the occasions on which the animal picked up one piece can be used for this, and from the above figures (93 times on the right and 89 on the left) we find that the right hand was used for the picking up of the food 37 times on the right and 33 times on the left, and the left hand was used for taking the food which was 56 times on the right and 56 times on the left. In the case of this animal, therefore, the position of the food had no perceptible influence on the use of the individual hand.

In 185 of the tests with monkey 8, the animal took only one of the pieces of food which were before him; in 75 tests both pieces were taken. In the tests in which one piece of food was taken the right hand was used 32 times, the left 153 times; in the tests in which both pieces were taken the right hand was used 18 times for both pieces (total 36), the left hand 55 times (total 110), and both hands 2 (2 each). In the test in which the single pieces of food were taken the right hand was used for 15 pieces of food on the right and 17 on the left; the left hand 74 times for food on the right and 79 times for the food on the left. Although there is a slight difference in favor of taking the food on the left, the percentage is almost equal for both hands, and there is no apparent influence in this case of the position of food affecting the use of either hand.

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[8] For details see my monograph, cited above, pp. 44-52; 95-97.

The positions of the pieces of food in the tests with monkeys 2, 3, 6 and 7 were not noted on the records, and no data in regard to this matter can be given.

During the tests it was repeatedly noted that there were relatively long periods when each animal would use exclusively one hand in taking the pieces of food, followed by a period when the other hand was used. In a long series these alternations, if due to extraneous causes, should balance, but in the cases of monkeys 1, 6 and 8 after operation the series were not sufficiently long.

Although the data collected indicate as a whole that of six monkeys one showed an apparent preference for the use of the right hand (monkey 1), and two preference for the use of the left hand (monkeys 3 and 8), more observations are needed before any definite preferential use of the hands in monkeys may be accepted as proven. In view of the relation of the observations to the question of the origin of right or left handedness in man, the data are here given in the hope that other workers with monkeys may be tempted to make similar observations and publish their results.

# NOTES

## THE BEHAVIOR OF A GREY SQUIRREL

ELIOTT PARK FROST
*Yale University*

On last Thanksgiving morning the writer's lawn was covered by two inches of freshly fallen snow,—a depth sufficient to conceal all visible traces of the closely cropped grass. His attention was called to the behavior of a large grey squirrel, one of many that make their home in the neighborhood.

When first seen the squirrel was perched upon a wooden post some four feet from the ground, apparently making an interested survey of the landscape. From here he leaped lightly down across the snow, stopped abruptly and, raising himself on his haunches for an instant as if to detect possible disturbers, burrowed his nose in the snow and brought forth a buried nut. This he took in his mouth the length of the lawn, to the southerly, lee side of a large elm, where the snow was lightly fallen. Here the nut was superficially reburied under leaves, paws being chiefly employed.

Returning, the squirrel again climbed the post, surveyed the white ground as before, again skimmed across the lawn, and at a place 15 or 20 feet from the former cache, reclaimed another nut, transferred it to the elm, and similarly buried it with the first. The whole performance was repeated, while the writer watched, until eight nuts were brought together in one single cache. Three times he failed to climb the post before securing the nut. Once he burrowed without apparent result, but no further search was made. No two nuts were taken from the same place. Each nut found was unerringly detected and appropriated from under the untracked snow. At the conclusion of his task, which was performed in most business-like fashion in less than 10 minutes, the squirrel skipped away and was lost to view in a large elm across the street. This was the first snow-fall of the season. Whether the animal had weathered previous winters, the writer does not know.

Two distinct types of behavior are here correlated, first the precise detection and recovery of the buried nut; second, the assembling of the nuts at one single, protected spot. In his book, "Wild Traits in Tame Animals,"[1] Mr. Louis Robinson writes: "Squirrels will, without the least difficulty, find stores of nuts and acorns buried far from any tree or other perceptible landmark, even when the ground is covered by a recent layer of snow......" But the writer knows no literature which mentions the other type of behavior: the assembling and re-cacheing of food under these circumstances.

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[1] Robinson, Louis. Wild Traits in Tame Animals. Edinburgh and London, 1897.

# A REVIEW OF YERKES' AND WATSON'S "METHODS OF STUDYING VISION IN ANIMALS"[1]

By S. O. MAST

Nothing in the whole realm of literature on the behavior of animals shows as clearly as this monograph that we have outgrown the purely qualitative stage in this branch of science and have actually entered upon the quantitative phase. The monograph is indeed devoted almost entirely to methods designed for the prosecution and encouragement of work in this more advanced stage of the subject. The authors say on page 3: "Our standard procedures are recommended only for thoroughgoing, intensive, quantitative work. Simpler and more conveniently manipulated apparatus may be used in the case of preliminary exploratory work. We do not wish to discourage the use of crude and relatively uncontrollable methods for the study of vision, but we do most emphatically recommend that these methods be abandoned as soon as the rough problem-defining portion of an investigation has been completed."

These sentences state in admirable form the guiding principles of the whole investigation on methods. The authors apparently spared neither time nor labor in perfecting apparatus by means of which the ideal set forth in the quotation above could be attained. As a result we have an excellent description of the construction and working of a "Light or Brightness Apparatus" and a "Spectral Color Apparatus." Neither of these pieces of apparatus bears the slightest apparent relationship to the home-made variety with which most of us are familiar. They are in reality instruments of precision of the highest order, comparable in accuracy of construction and adjustment with a high grade microscope.

The light apparatus is adapted for the investigation of problems associated with brightness, size or form. By means of it animals can be simultaneously subjected to light from two sources, (1) of the same size and form but differing in intensity, (2) of the same intensity and size but differing in form, and

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[1] Behavior Monographs, vol. 1, no. 2.Pp. IV + 90.

(3) of the same intensity and form but differing in size. The special relation of the two sources of light can be reversed and the intensity accurately controlled and measured.

The spectral color apparatus is designed for the investigation of problems concerning color. By means of it animals can be subjected, (1) to monochromatic light of various intensities and exceptional purity from any region of the spectrum, (2) simultaneously to two beams of light of precisely the same wave-length but of different intensities, and (3) simultaneously to two beams of light of different wave-lengths but either of precisely the same or of different intensities. The light in these beams can be selected from any two regions in the spectrum. Their relative position can be readily and almost instantaneously reversed. And the intensity can be accurately controlled, measured and compared in terms of energy.

It would be superfluous to attempt even a general description of either of these two pieces of apparatus. The monograph should be in the hands of every one in any way interested in reaction to light either in animals or in plants, perhaps not even so much owing to the discussion bearing on these special pieces of apparatus as to that bearing on the nature and experimental value of light artificially produced in various ways and that concerning the nature and production of colors by means of screens, filters and reflecting surfaces of various sorts.